WHAT ON EARTH IS ENERGY?

POPULAR SCIENCE SERIES

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POPULAR SCIENCE SERIES

What on Earth is ENERGY?

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NATIONAL COUNCIL OF EDUCATIONAL RESEARCH AND TRAINING

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Back Cover
The Milky Way: It is a galaxy There are more than 100 billion stars in this galaxy Our Sun is just one of them Most of our energy comes from the Sun

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FOREWORD

It has been a continued endeavour of the NCERT to make Indian children aware of Science in their everyday life and to demystify it through popular science books. It is not an easy task when we consider that superstitions still guide a majority of Indians and block the percolation of science into our psyche. It is necessary for us to realize that science is not extraneous to us. We are a part of Science. It is our children who have to be told this and told in a manner that interest them.

It is with this objective and with the inspiration of Professor C. N. R. Rao, F.R.S., Director, Indian Institute of Science, Bangalore, that the NCERT has launched the project of bringing out a series of books on subjects which are an integral part of our existence. Professor S. K. Biswas of the Indian Institute of Science has been helping as a co-ordinator. This book on Energy is the first of this series.

Raja is a young boy from a middle class family from a semi-urban area, who lives in a world of reality and fantasy. He is exposed to some hard facts on Energy at his school or from textbooks and sorts them out with his friends from the animal world. Raja constitutes a character throughout this series in the hope that children of his age group identify themselves with him and learn about various things around them.

Professor D. P. Sen Gupta of the Indian Institute of Science has spent many months in writing, visualizing and designing this book in the fond hope that our children may learn the Physics and Chemistry involving "Energy" which constitutes one of the most important ingredients of our life. The illustrators have made this book really attractive.

Our efforts, however, will be successful, only when this book is accepted by children for whom it is meant.

Thanks are due to Prof. B. Ganguly, Head, Department of Education in Science and Mathematics, NCERT, who is also the Coordinator of this Popular Science Writing Project, and to Shri C. N. Rao, Head, Publication Department, NCERT for their efforts to make this Project successful.

P.L. Malhotra
Director
National Council of
Educational Research and Training

New Delhi

PREFACE

This book is intended for children in the age group of eleven and thirteen. They would have been taught most of the basic concepts that have been dealt with in this book. But this is not a textbook. Our children are already inundated with textbooks and saturated with information. They should be made aware of the environment in which they are growing up and 'Energy' is an inseparable ingredient of that environment.

The inspiration for this book came from Professor C.N.R. Rao, Director of the Indian Institue of Science and the main motivation came from my colleague, Professor Sanjay Biswas.

A large number of friends have helped me in this effort. I am indebted to all of them but I can mention only a few. Foremost among them are Shri B.G. Gujjarappa who did all the illustrations, Shri Samir Mandal who coloured the drawings and Shri Ramesh Rao of Scion Advertising who organised the preparation of the camera-ready copy of the book in a very short time. Smt. Y.A. Rakma and Smt. M.V. Manjula typed the manuscript. Shri Jayant Rao and Shri Nagaraj provided some of the lovely photographs without any charge I am grateful to all of them. Professor A.K.N. Reddy, Dr. Margaret Biswas, Dr. Manju Bansal and Dr. Indraneel Sen who are my colleagues in the Institute, checked through the manuscript and made valuable suggestions. I am particularly indebted to my eldest brother Shri Sailesh Sen Gupta and Professor C.V. Vishveshwara of the Raman Research Institute with whom I have had extensive discussions.

I thank Dr. P. L. Malhotra, Dr. B. Ganguly, and Shri C. N. Rao of the National Council of Educational Research and Training, New Delhi, for their deep involvement in the publication of this book. Thanks are due to Shri Biren Das of K. C. Das, Pvt. Ltd. for welcoming the author to hold several meetings in his house during the preparation of this book.

I am grateful to my wife Nandita and children Kundan and Roopsha who have been extremely patient with me when I was writing and designing this book and served as my first targets.

D.P. Sen Gupta
Indian Institute of Science
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About This Series

The only way we can bring a transformation of our society is by inculcating proper attitudes in our young people. An effective way of doing this is through pictorial books which convey the scientific spirit without being a formal part of instruction. The Science Advisory Council to the Prime Minister recognised the importance of such an effort and Shri Rajiv Gandhi, our Prime Minister, spontaneously gave the encouragement to proceed with this project. It is most heartening that we have found enthusiastic scientists who are able to produce such work. Dr. P.L. Malhotra, Director, National Council of Educational Research and Training and his colleagues have wholeheartedly responded to this effort. I hope that we can produce a number of such books in the near future not only in English and Hindi, but in all other Indian languages.

C N R RAO

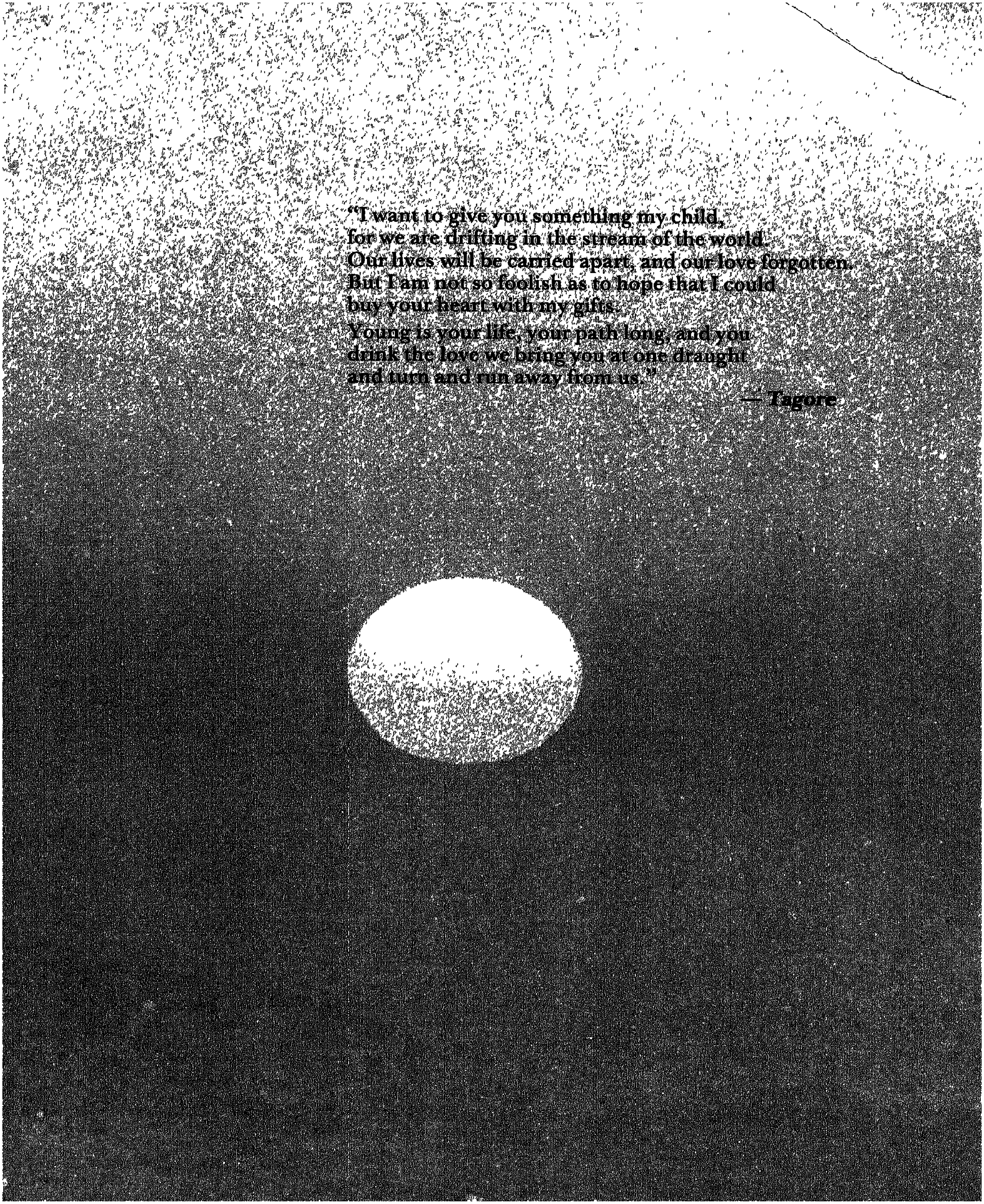
GANDHIJI'S TALISMAN

"I will give you a talisman. Whenever you are in doubt or when the self becomes too much with you, apply the following test :

Recall the face of the poorest and the weakest man whom you may have seen and ask yourself if the step you contemplate is going to be of any use to him. Will he gain anything by it ? Will it restore him to a control over his own life and destiny ? In other words, will it lead to Swaraj for the hungry and spiritually starving millions ?

Then you will find your doubts and your self melting away."

mkGandhi



"I want to give you something my child,
for we are drifting in the stream of the world.
Our lives will be carried apart, and our love forgotten.
But I am not so foolish as to hope that I could
buy your heart with my gifts.

Young is your life, your path long, and you
drink the love we bring you at one draught
and turn and run away from us."

— **Tagore**

Does most of our energy come from the Sun?

(Raja meets his friends in a forest)

Raja: Professor Owl, Vidwan Markata and friends! Our science teacher told us that most of the energy on the earth comes from the Sun. I find this hard to believe. Do you think she is right? We invite Sthula, the elephant, who is the strongest animal to tell us whether he gets his energy from the Sun or not.

Pashuraj, the lion: Sthula is not the strongest animal. I am ready to fight with that fatso and prove that I have more energy than he has.

Owl: Silence! No ill-manners please. Mr. Pashuraj, let me tell you this. You may have power but that does not mean you have more energy than an elephant.

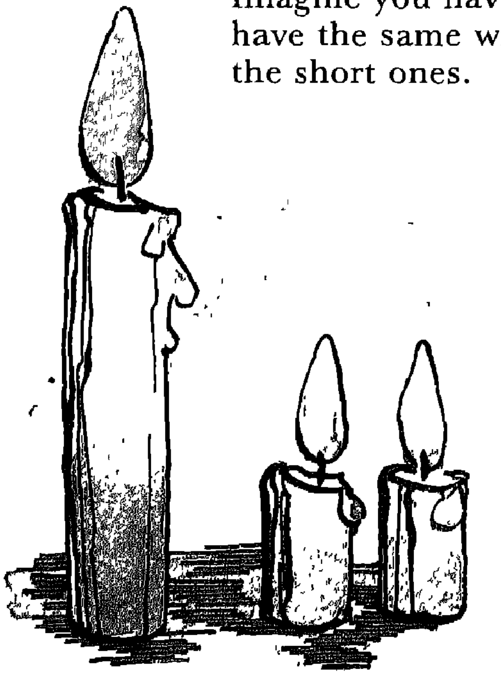
POWER AND ENERGY ARE NOT THE SAME

Pashuraj: Rubbish! .

Owl: Please listen to me. I admit that Pashuraj is very strong and he can kill a big animal with one stroke. Surely that needs power. But an elephant can lift a huge log, he can carry weights over long distances. That needs energy. Is it clear?

Everyone in a chorus, "No."

Owl: All right, all right. Let me give you another example. Imagine you have two short candles and one long candle. The candles have the same width, only the long candle is three times as long as the short ones.

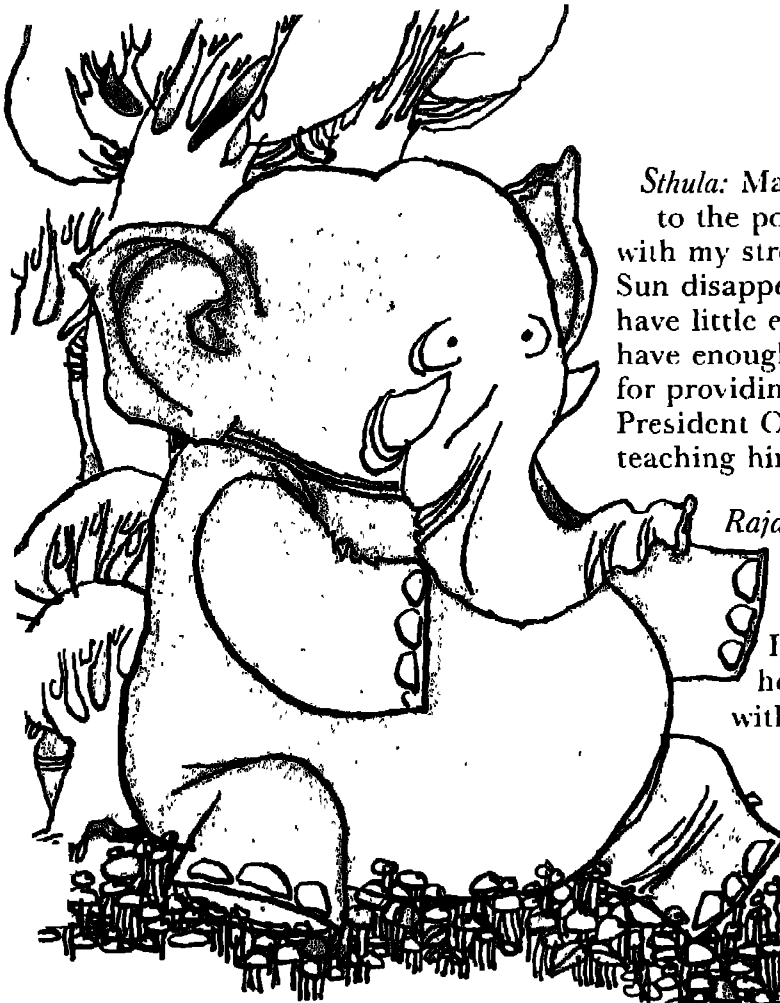


If you burn the two short candles together you have twice as much light or POWER as when you burn the long candle. But if the two short candles burn for one hour, the long candle burns for three hours because it is three times as long.

Which of these gives more energy?
The long candle because it has more wax in it.
(1 candle power × 3 hours) is greater than
(2 candle power × 1 hour)

Energy is Power multiplied by Hour
By hour, I mean TIME
So come on let's chime,

ENERGY IS POWER MULTIPLIED BY HOUR



Sthula: May I go on with my speech? Well, coming to the point, I do not see what the Sun has to do with my strength. True, I feel a bit cold when the Sun disappears at night. True, I feel very weak and have little energy left for doing anything if I do not have enough to eat. And I am grateful to the trees for providing me bark, leaves, fruit and energy. President Owl. Raja's science teacher has been teaching him silly things.

Raja: We have Pashuraj as our next speaker.

Pashuraj: Mr. President! Although I do not like Sthula very much, because he challenges my strength, I agree with him.

I do not like to lie in the Sun when I sleep and there are only two things that I need. Food and water.

Like the Elephant, I also feel weak if I do not have enough food. But I do not eat all the time as some of our friends do. If I have one big meal, I am happy for a couple of days.

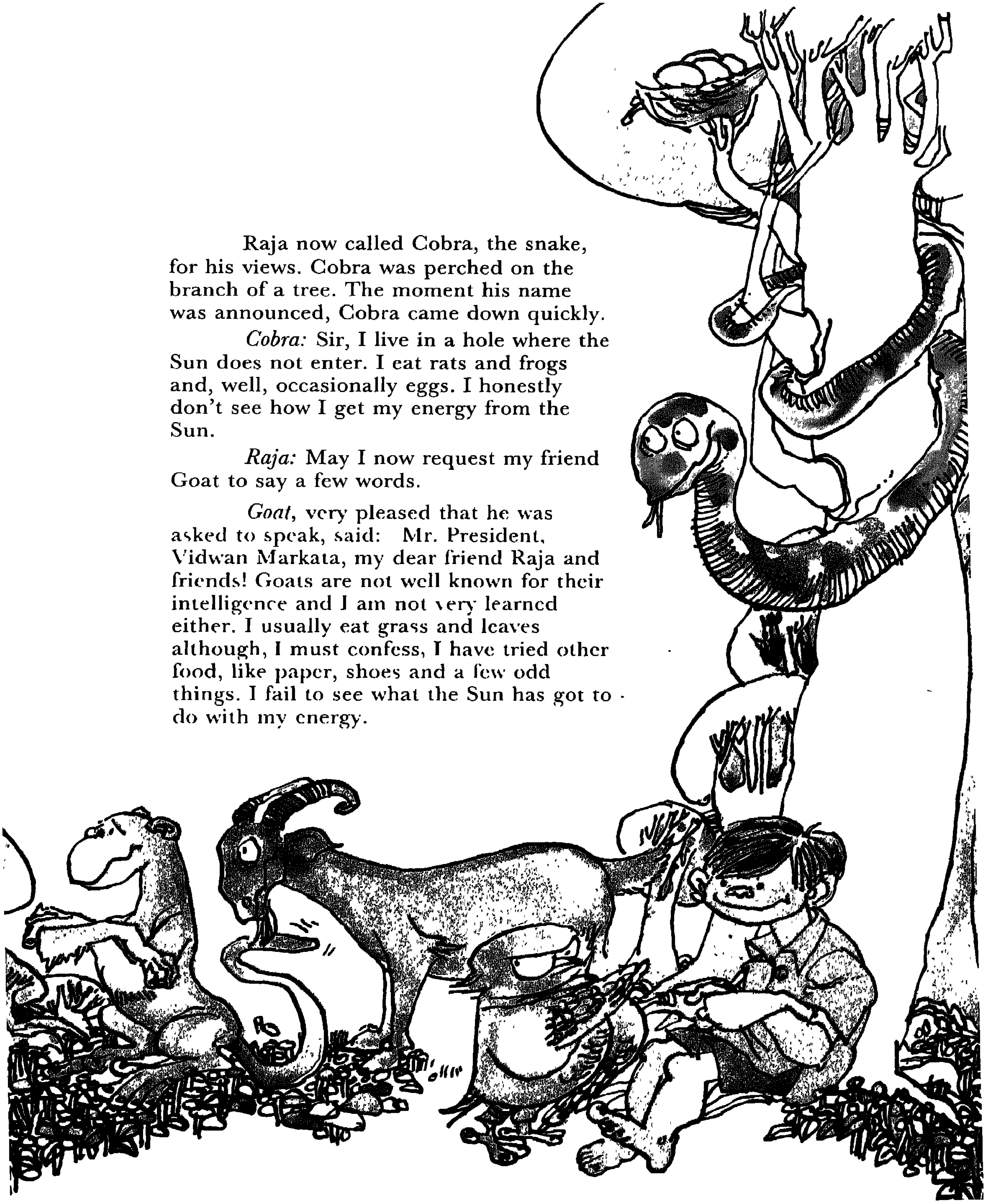
I do not see what the Sun has got to do with my strength or my energy.

Raja now called Cobra, the snake, for his views. Cobra was perched on the branch of a tree. The moment his name was announced, Cobra came down quickly.

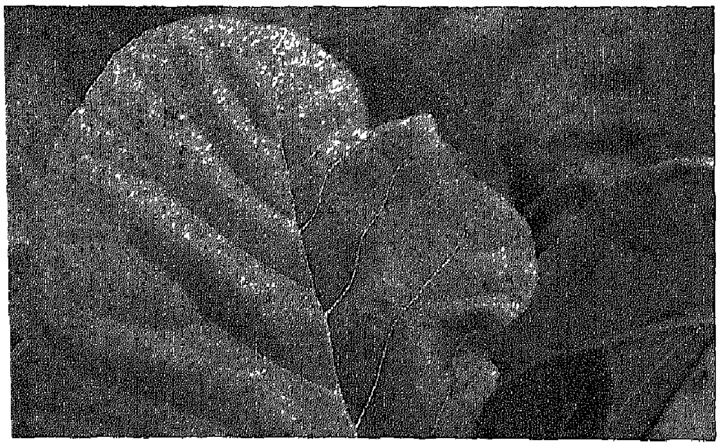
Cobra: Sir, I live in a hole where the Sun does not enter. I eat rats and frogs and, well, occasionally eggs. I honestly don't see how I get my energy from the Sun.

Raja: May I now request my friend Goat to say a few words.

Goat, very pleased that he was asked to speak, said: Mr. President, Vidwan Markata, my dear friend Raja and friends! Goats are not well known for their intelligence and I am not very learned either. I usually eat grass and leaves although, I must confess, I have tried other food, like paper, shoes and a few odd things. I fail to see what the Sun has got to do with my energy.



I cannot live without sunlight



It was at this point that one of the trees started making a hissing sound and everyone fell silent. No one had ever heard a tree make such a sound before.

Then the tree started speaking in a whisper:

I can't even remember those days. I was coming out of the earth and I remember feeling a terrible hankering for sunlight as two leaves sprouted out of me.

At first I did not understand why I had this hankering. Slowly I found that if I did not have the Sun on me, I would starve. My roots sucked water which flowed into my leaves. The leaves breathed through the tiny holes on their surface and my food would be prepared with the help of the green substance in the leaves. If some of the trees did not have sunlight, their leaves would turn yellow. They would then wither away and die. I had a hard struggle because there are so many tall trees around that the Sun did not reach everywhere. Many of my leaves died and I felt sad. But then I grew taller and taller and stretched my branches towards the sky so that my leaves could receive sunlight. We would die without the Sun.

Owl: Did you hear what the tree said? The green substance is called chlorophyll. With the help of sunlight it can break-up water molecules into Oxygen and Hydrogen. The leaves breathe in Carbon dioxide and these elements and compounds all combine to make glucose and other food substances which we eat, I mean most of you eat.

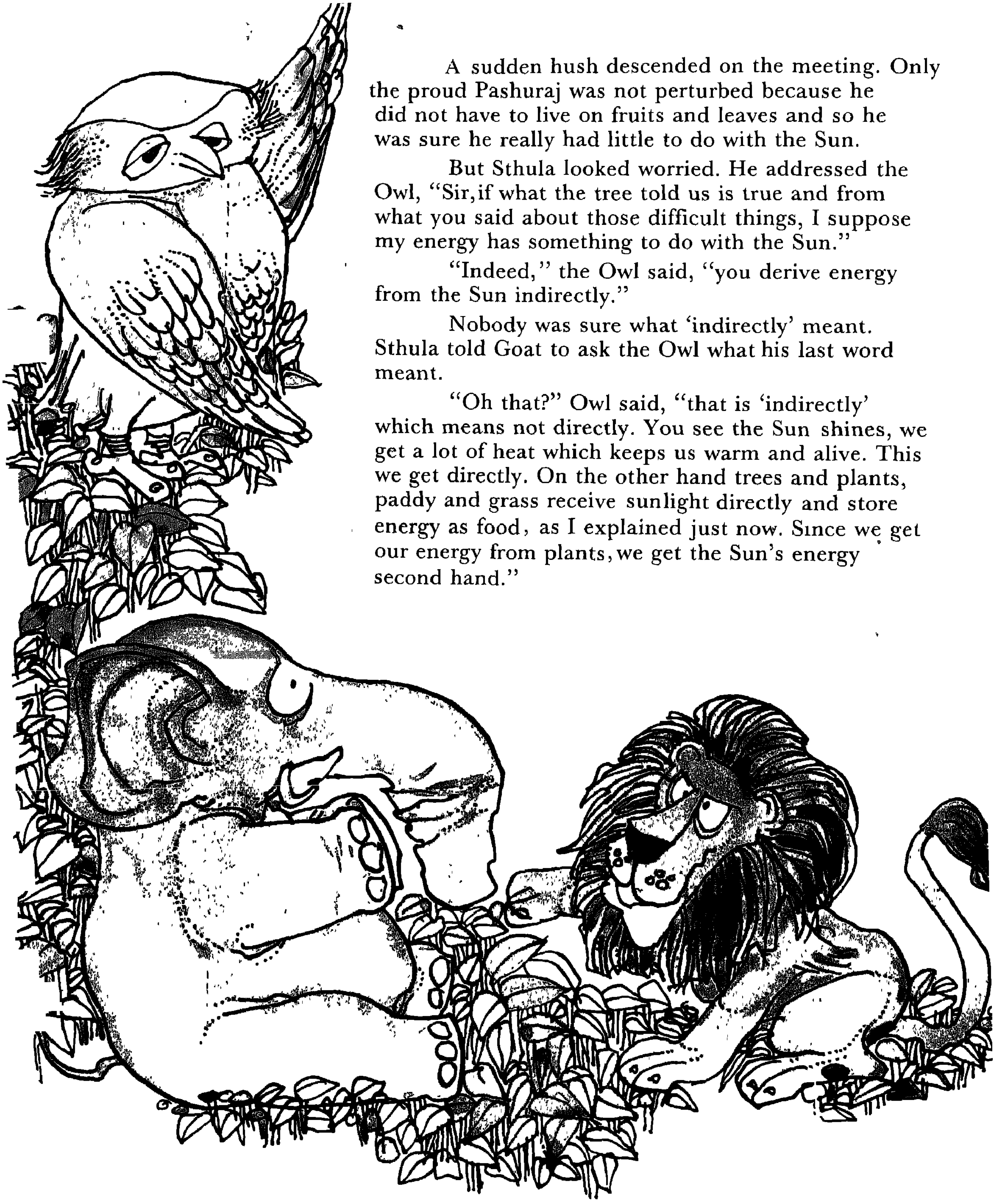
A sudden hush descended on the meeting. Only the proud Pashuraj was not perturbed because he did not have to live on fruits and leaves and so he was sure he really had little to do with the Sun.

But Sthula looked worried. He addressed the Owl, "Sir, if what the tree told us is true and from what you said about those difficult things, I suppose my energy has something to do with the Sun."

"Indeed," the Owl said, "you derive energy from the Sun indirectly."

Nobody was sure what 'indirectly' meant. Sthula told Goat to ask the Owl what his last word meant.

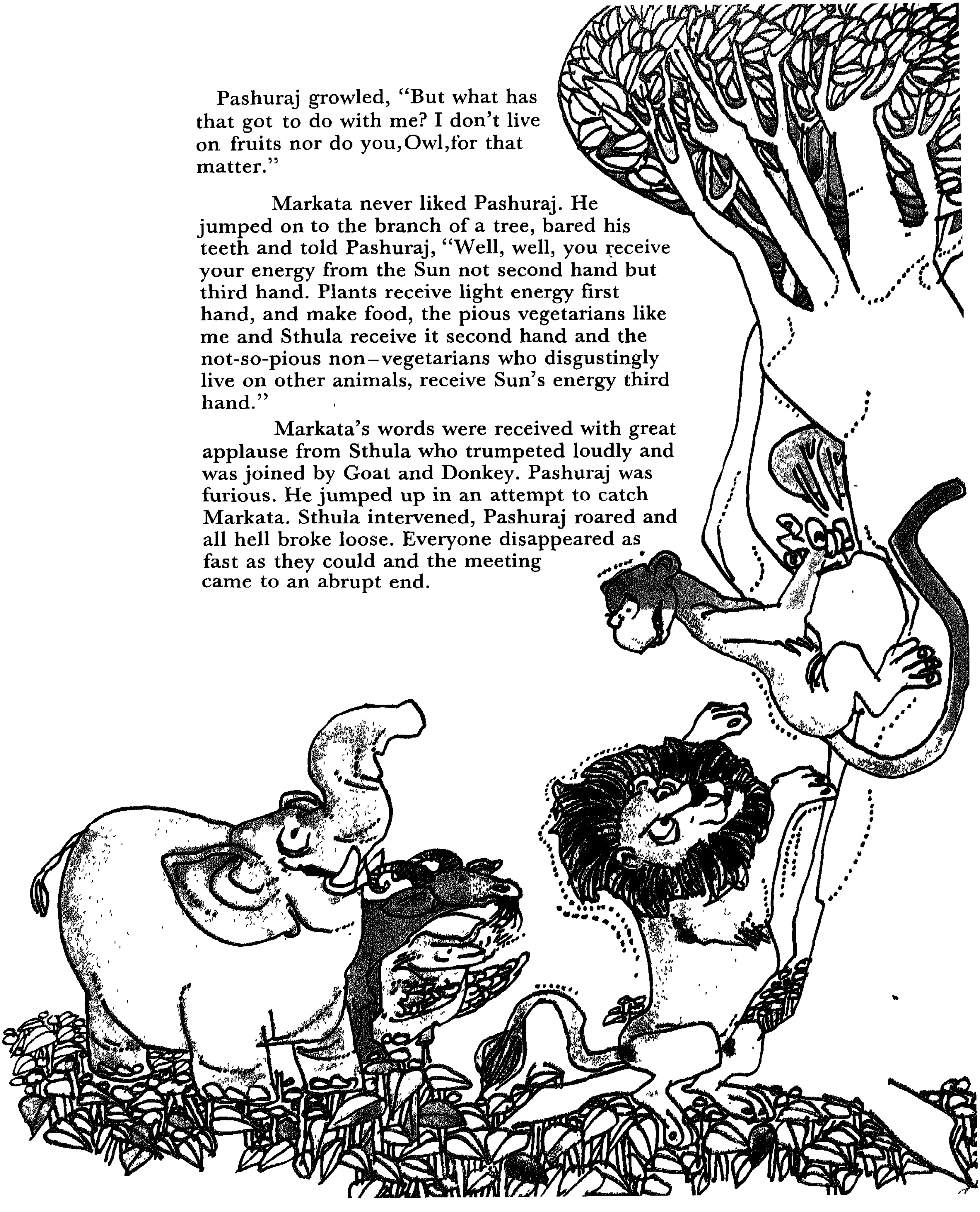
"Oh that?" Owl said, "that is 'indirectly' which means not directly. You see the Sun shines, we get a lot of heat which keeps us warm and alive. This we get directly. On the other hand trees and plants, paddy and grass receive sunlight directly and store energy as food, as I explained just now. Since we get our energy from plants, we get the Sun's energy second hand."



Pashuraj growled, "But what has that got to do with me? I don't live on fruits nor do you,Owl,for that matter."

Markata never liked Pashuraj. He jumped on to the branch of a tree, bared his teeth and told Pashuraj, "Well, well, you receive your energy from the Sun not second hand but third hand. Plants receive light energy first hand, and make food, the pious vegetarians like me and Sthula receive it second hand and the not-so-pious non–vegetarians who disgustingly live on other animals, receive Sun's energy third hand."

Markata's words were received with great applause from Sthula who trumpeted loudly and was joined by Goat and Donkey. Pashuraj was furious. He jumped up in an attempt to catch Markata. Sthula intervened, Pashuraj roared and all hell broke loose. Everyone disappeared as fast as they could and the meeting came to an abrupt end.



It was Raja's science class:

Miss Leela, Raja's science teacher, walked in with a handful of charts and hung them on the wall. One of the charts had a short verse written on it.

"Of all the energy the sun gives us
Half is heat and half is light,
Heat gives warmth and wind and rain
Light gives fuel and food and sight."

It was a hot day. Bipin stood up and said, "Miss, we could do with less heat, couldn't we?" Bipin always asked such questions.

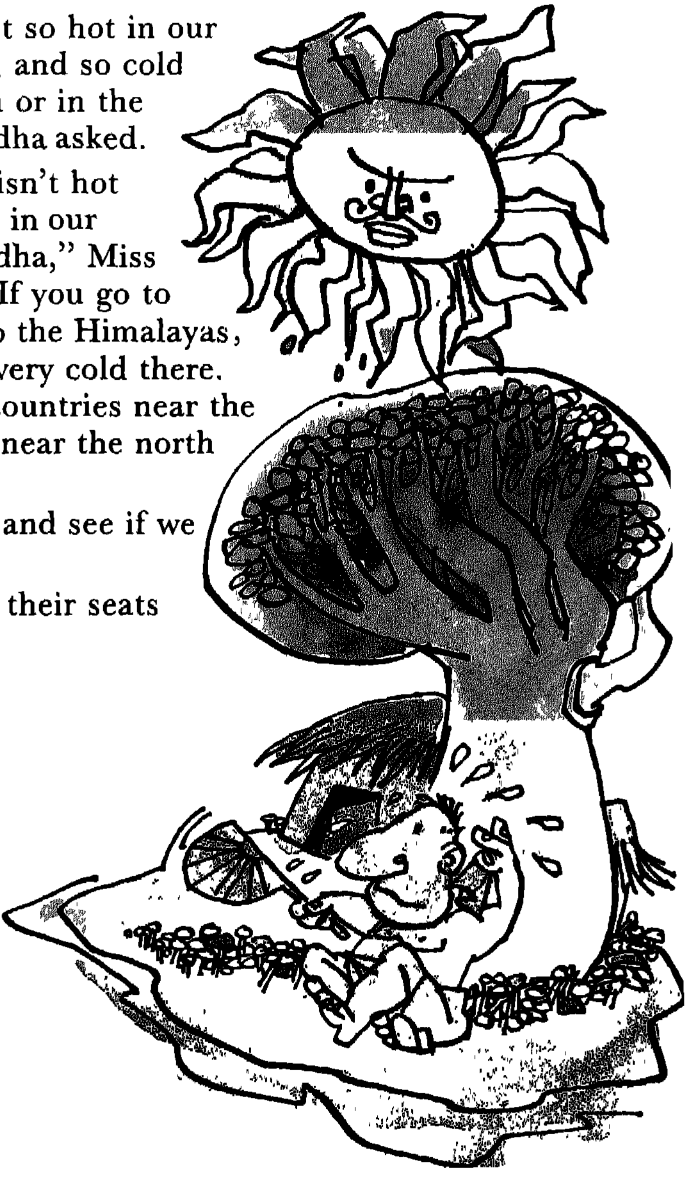
"If you ask the Eskimos in Greenland or even the Englishmen they would say just the opposite, Bipin." Miss Leela said.

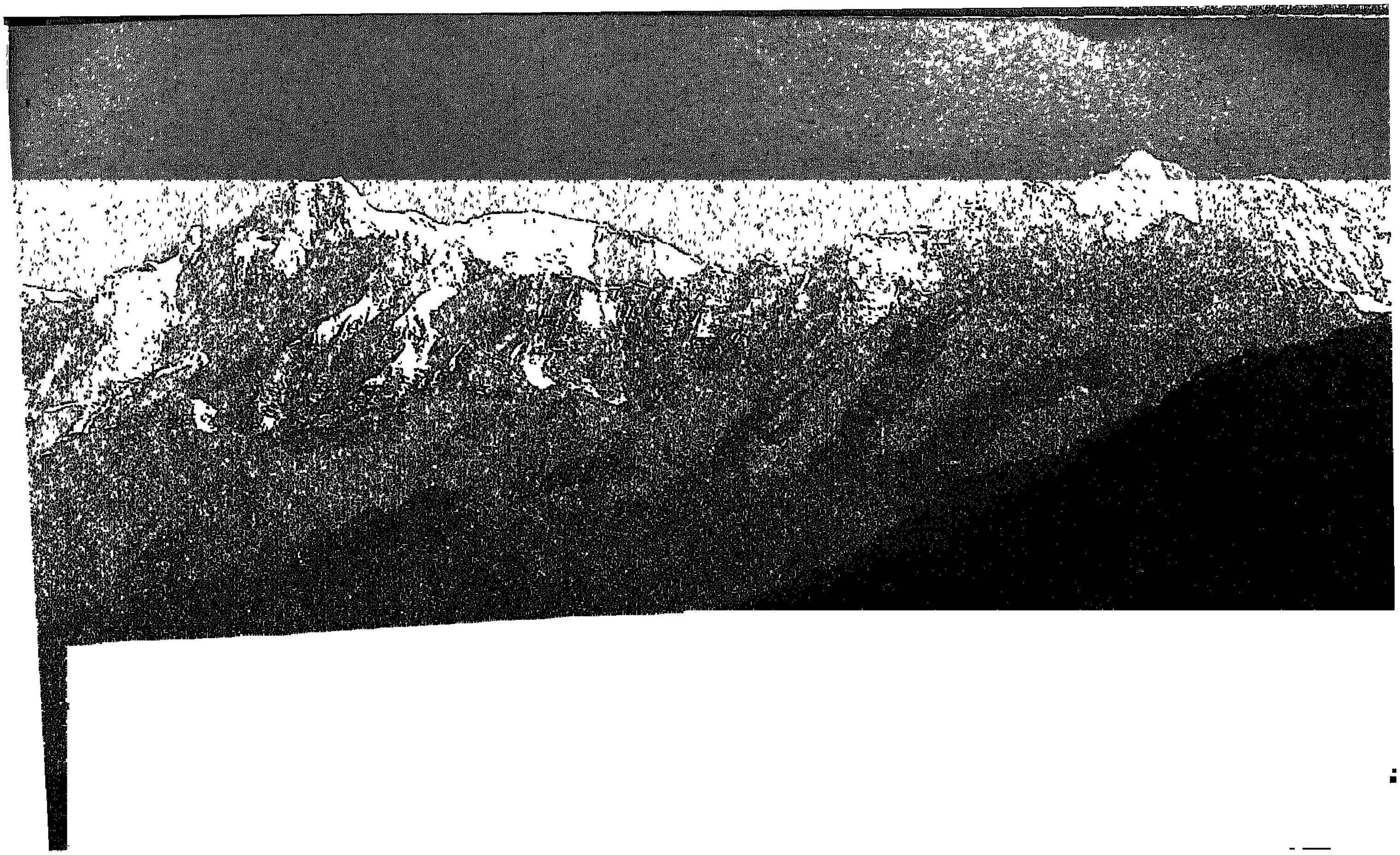
"Why is it so hot in our country Miss, and so cold in the North or in the South?" Sudha asked.

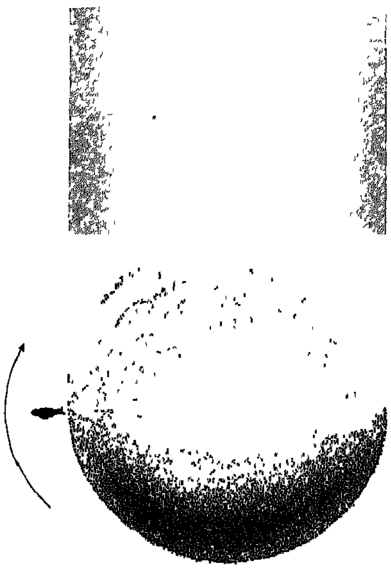
"It isn't hot everywhere in our country, Sudha," Miss Leela said. "If you go to Kashmir or to the Himalayas, you will find it very cold there. But in general, the countries near the equator are warm and those near the north and south poles are cold.

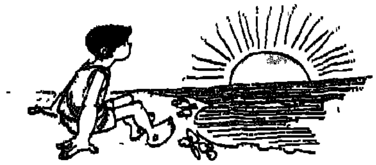
Let us look at these charts and see if we can find why it should be so."

The students instantly left their seats and crowded near the charts.

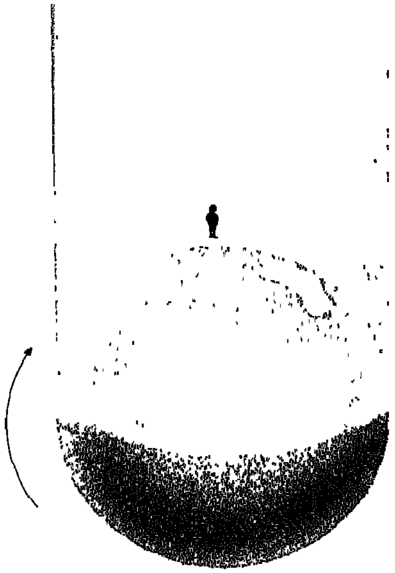


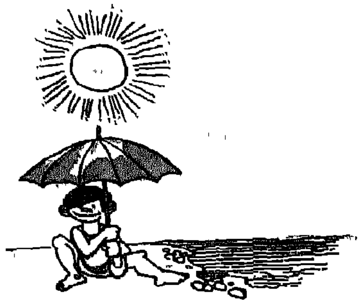






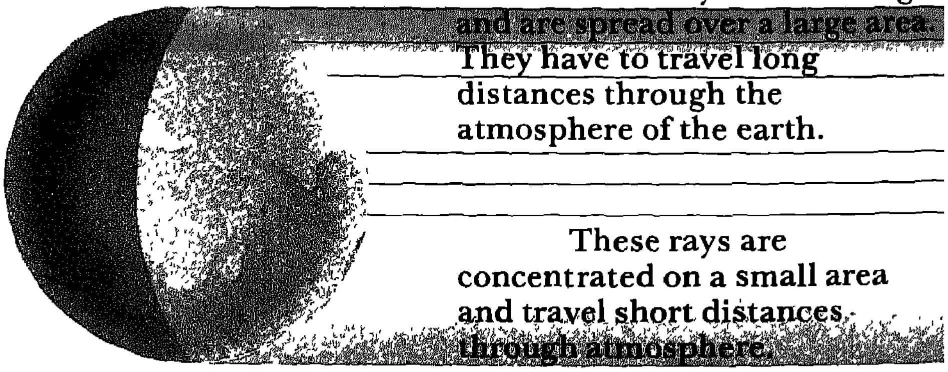
It is six O'clock in the morning. It seems to me that the Sun is in the horizon. I call it sunrise. The Sun is red. The rays are soft. The rays that reach me are slanting and spread on a large curved area. The rays also had to travel long distances through the earth's atmosphere which absorb some colours and heat. That is why the Sun appears red and cool.





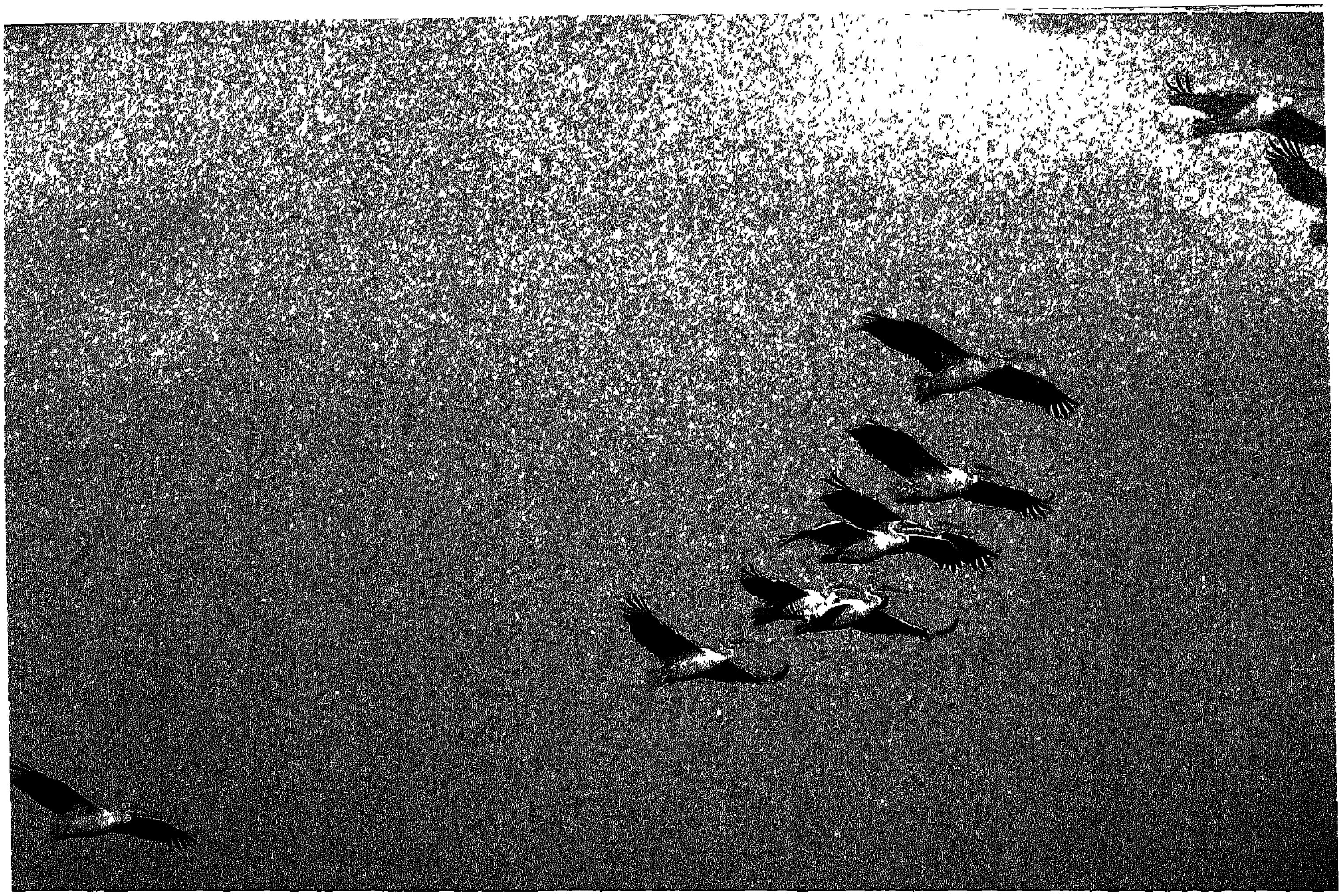
It is 12 noon. The Sun is directly above my head because I have rotated with the earth. The rays are concentrated on a small area and feel very strong. The rays come straight or directly and travel a relatively short distance through the atmosphere. The Sun looks dazzling. It feels very hot.

As the Sun appears mild and cold, to us only during the morning, it appears mild and cold in the North and the South all the time.



These rays are slanting and are spread over a large area. They have to travel long distances through the atmosphere of the earth.

These rays are concentrated on a small area and travel short distances through atmosphere.



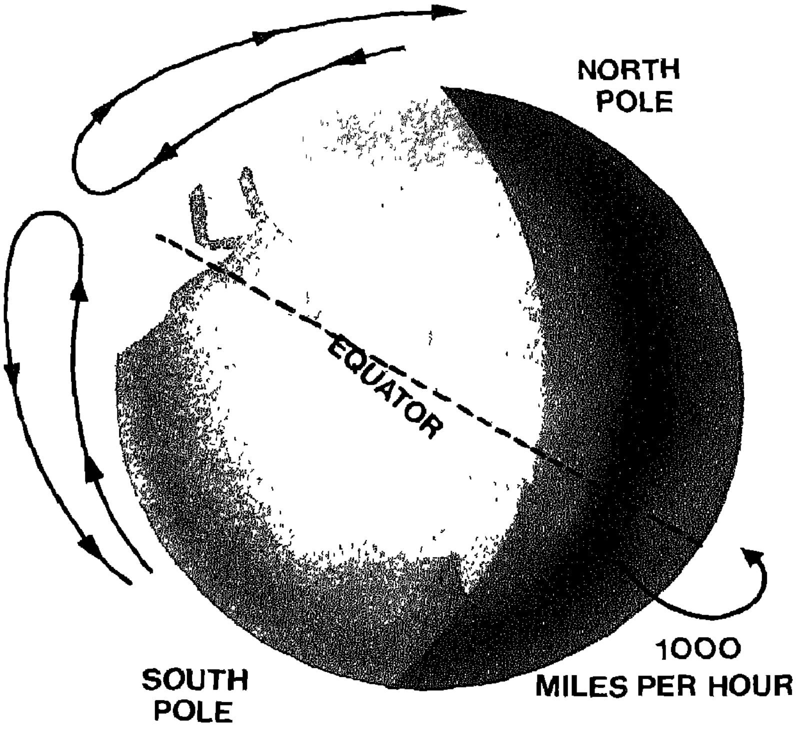
In search of food and warmth

In summer when days are longer in Northern parts of the world, millions of birds breed and feed there. Longer days help food hunting. This is essential since young birds in the nest need enormous amount of food, many times their own weight. When autumn comes and days get shorter and colder in the North, a thousand million birds migrate South in search of food and warmth. From Europe birds migrate to Africa and from North America to the warm sunny lands of Central and South America.

Some birds make incredibly long journeys. The Arctic Tern is known to make an annual journey of 22,000 miles. Where do birds get energy for such long flights? Some migrants feed on the way. Others get their energy by storing food as body fat before they start. Besides, they waste very little energy and take advantage of the winds. It is surprising how migratory birds migrate and find their destination with such accuracy.

The birds shown above are pelicans. They migrate from Southern Europe as food gets scarce during winter. A pelican needs over 1 kg of food every day. Here they are seen heading towards Bharatpur in Rajasthan.

What makes the wind blow?



If air is heated, its volume increases. It becomes lighter and moves upwards.

Since it is much hotter near the tropics and the equator than it is near the poles, the hot air around the equator moves up and the denser air from the poles comes to fill its place.

That is how the heating of the earth's surface sets up winds and the earth's atmosphere acts as a giant heat engine.

You have to remember two other things. One is that water in the seas heats and cools more slowly than the land. If you stand near the sea on a hot summer day, you will feel that the breeze from the sea is still cool.

The other thing to remember is that the earth rotates and at the equator it has a speed of nearly 1600 kms an hour, faster than a jet plane. Because of this speed, the air gets churned and the direction of wind is not just from the poles to the equator and back.

Wind speed can be very high, as high as 200 kms per hour or more. Very strong winds may cause a lot of damage. Winds cause big waves on the oceans.

For us in India, monsoon winds carry clouds and we get the rains which we badly need.

Wind energy has been used to drive sailing boats which can travel across the oceans. The earliest record of sailing boats is about 4000 BC.

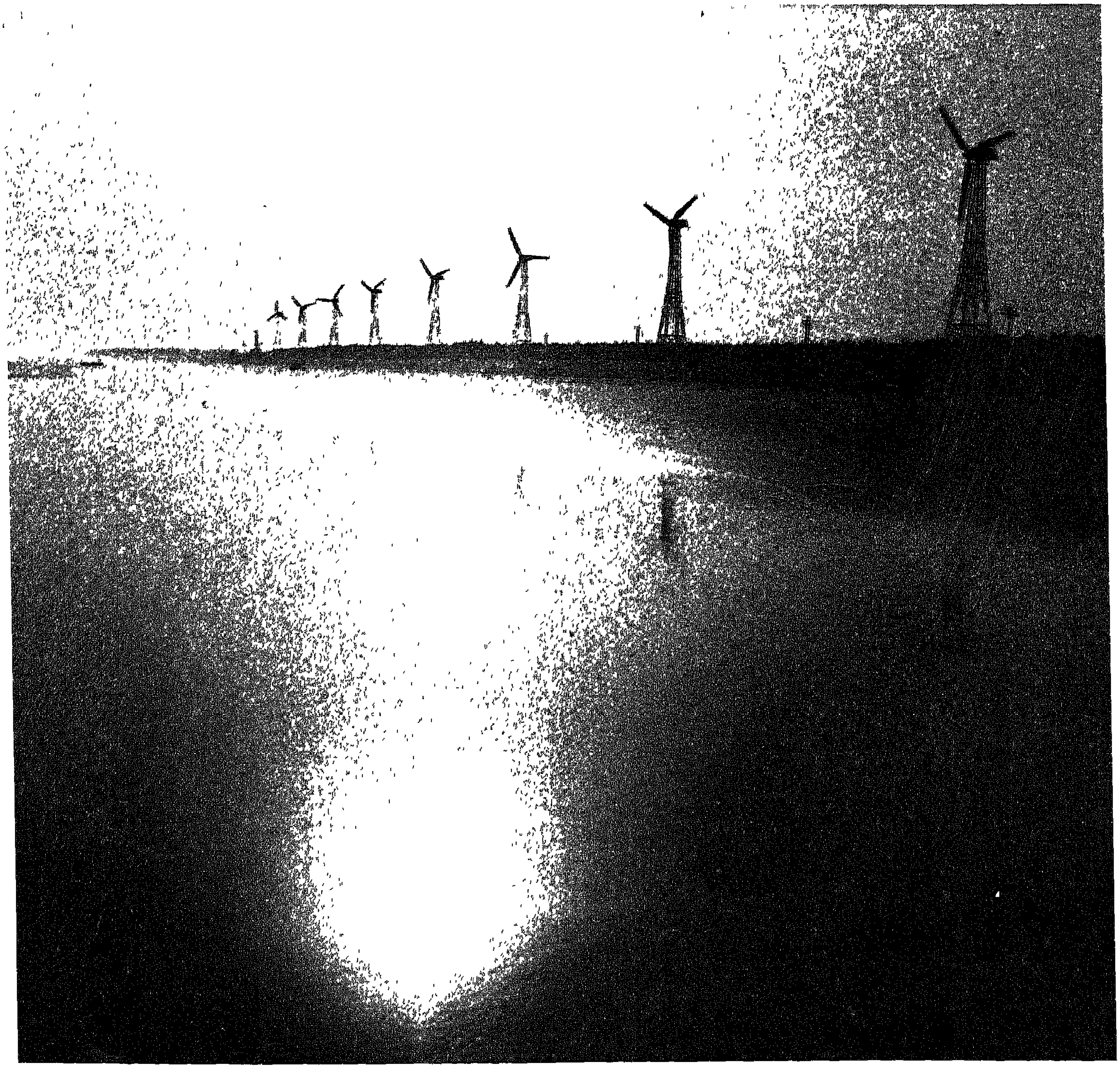
Wind was used for centuries to pump water and for milling grains.

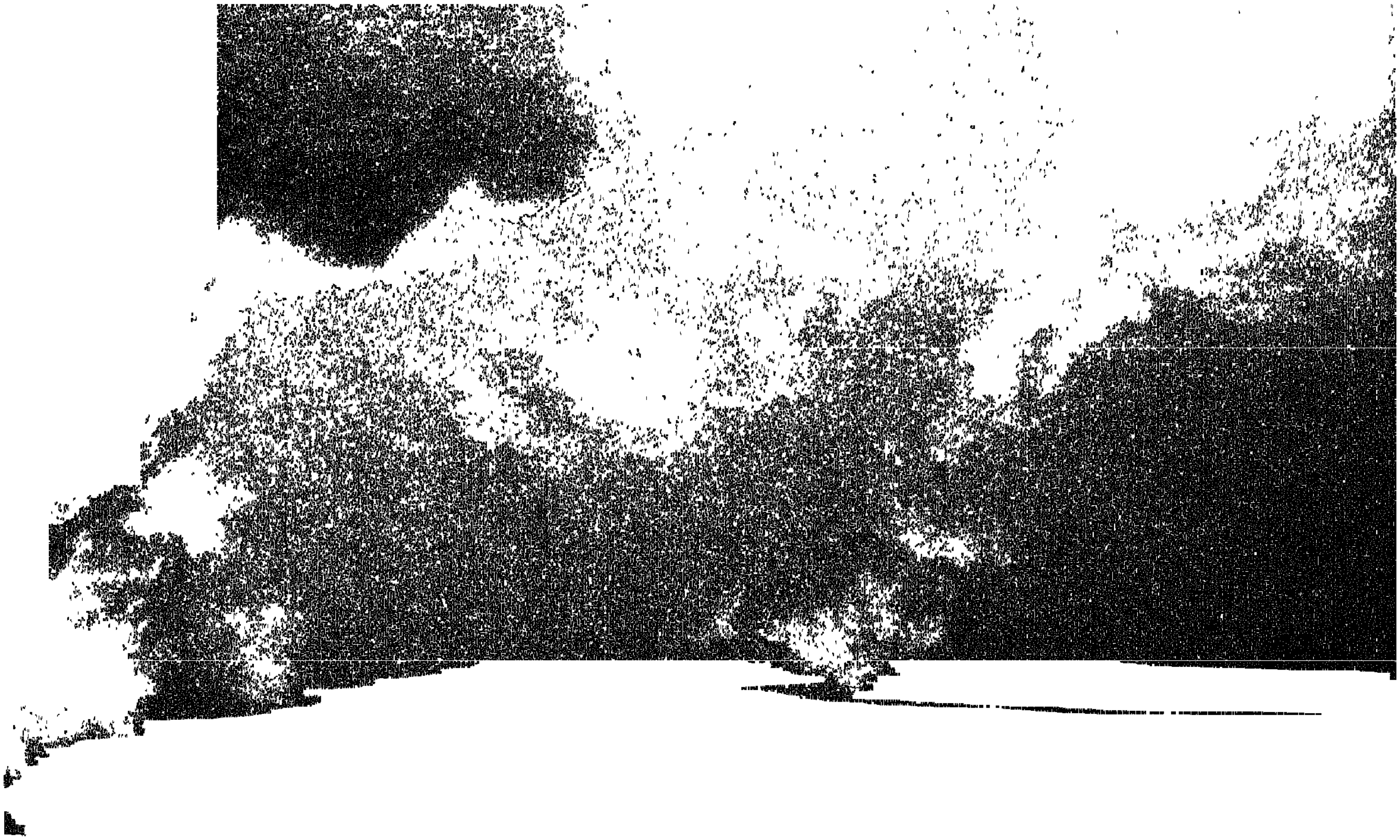
Wind power is now being used to generate electric power.

A wind farm

When wind blows, the blades of windmills rotate and turn electric generators. Electricity produced flows to electric wires connected to the generators.

The wind farm at Puri, Orissa, has 10 windmills, each generating 55 kW. One kW can light ten 100 Watt bulbs.





What causes rain?

We can't see it, but it is happening all the time. As the Sun heats the water in the oceans and lakes, vapour is formed and being lighter than air, water vapour moves up.

We see this when it gathers into clouds. Clouds are made of tiny droplets of water.

The vapour in the cloud is condensed when it is cooled and gathers as rain drops around dust particles. These drops become heavy and come down as rain.

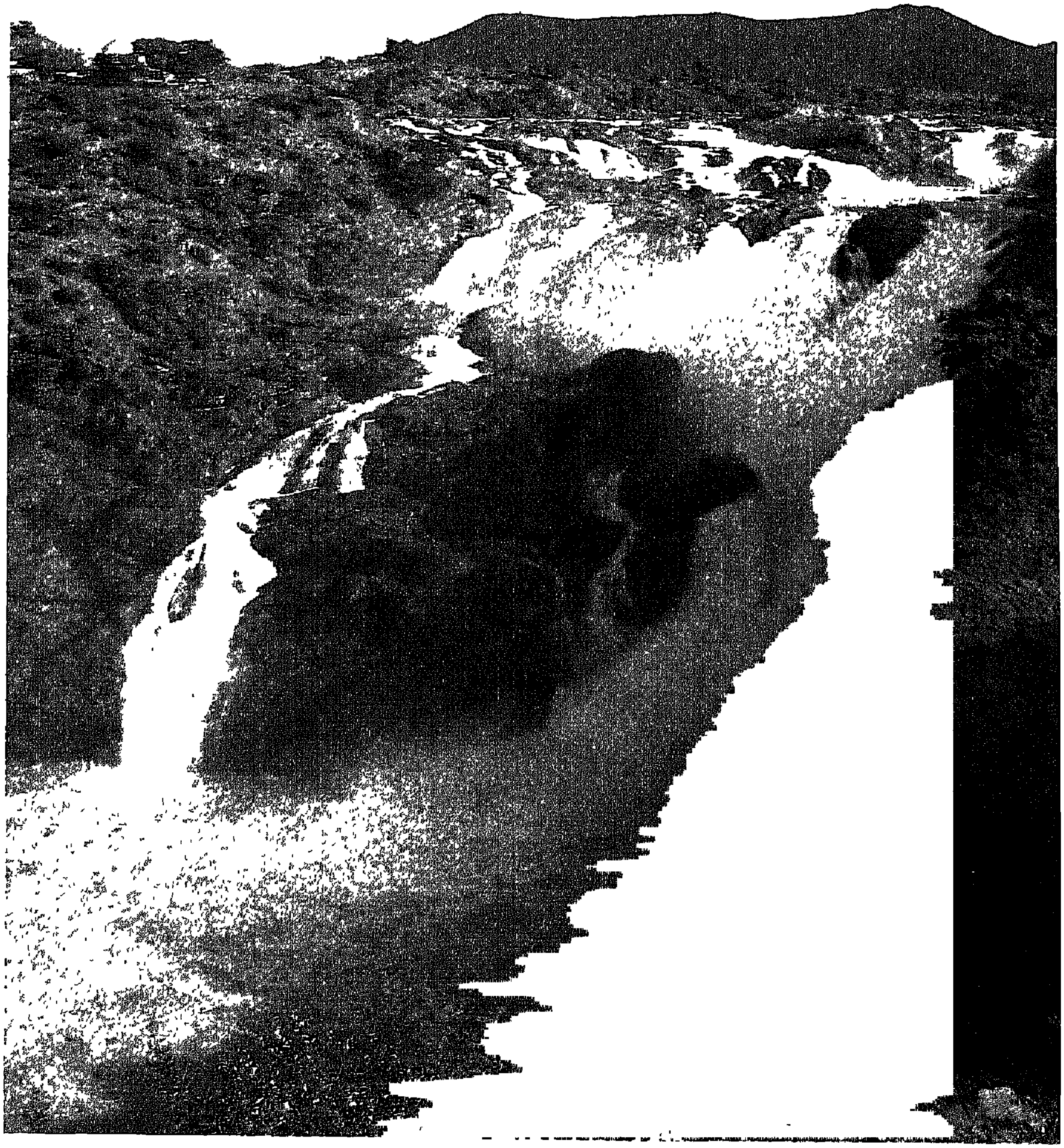
Rain water is soaked up by the earth. This water feeds plants and trees and gives us food and water.

Rain water gathers as snow and ice on mountains and can turn into big glaciers.

Glaciers melt and rivers flow out of them. Our Ganga flows out from the Gangotri glacier, travels through Uttar Pradesh, Bihar, West Bengal and meets the Bay of Bengal.

Water comes out of the sea and flows back into it. What keeps the cycle going? The Sun of course. A part of the Sun's energy that goes into evaporating water, reappears when rivers flow down the hills in great force. This energy is used to produce electricity. We call it hydroelectricity. It keeps renewing itself as the water cycle goes on.

About a third of the Sun's energy reaching the earth every year, evaporates and lifts 416,817 cubic kms of moisture from the seas, lakes, rivers and streams. The water comes down as rain and flows back to its sources.



What is gravity?

If you have two stones,
one big, one small
and drop them from the same height together,
"There is no doubt at all
which is the first one to fall,"
everybody said, "it must be the heavier."
But Galileo Galilei
said, "I disagree,"
and dropped them from an inclied tower.
Lo and behold!
Just as he had told,
the stones hit the ground together.

"Does all our energy come from the Sun?" Raja asked his father.

"Most of it," father said, "but there is also gravitational energy which has other origins."

"What is gravitational energy?"

"Let me first tell you about gravitation. Have you ever thought why a stone should fall to the ground and not go up?

GALILEO GALILEI of Italy and ISAAC NEWTON of England, two of our greatest scientists, tried to find an answer to this question."

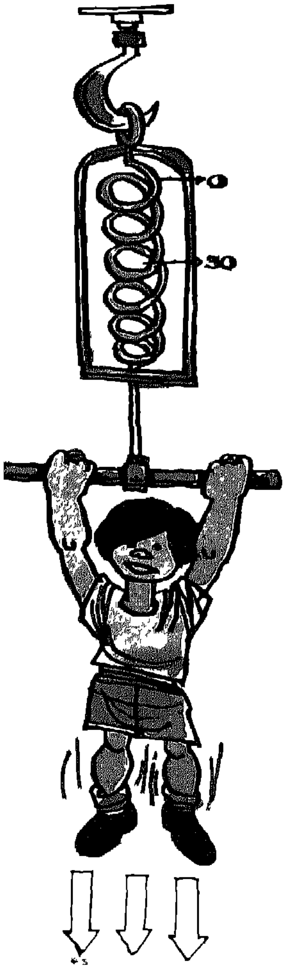
Galileo Galilei was born in Italy in 1564. Galileo built a thermoscope which is said to be the first modern thermometer. He perfected the telescope with which he searched the heavens and made many discoveries in astronomy. Galileo was prosecuted by the Church for preaching that the earth moves round the Sun.

It is said that Galileo, when he was a young boy observed that the number of oscillations made by a hanging lamp in a Cathedral was independent of the extent of its swing. He measured the oscillation by counting his pulse. Coming home he carried out several studies on pendulums.

Why don't you suspend different sizes of stones from strings of different lengths and see how the frequency of oscillation depends on the length of the string or the size of the stone?

Do we attract each other?

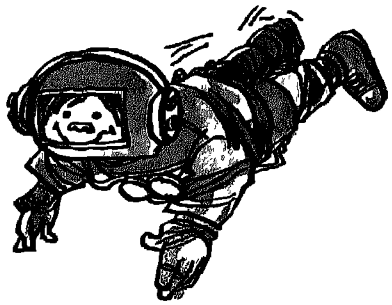
"Do you and I attract each other father?"
"We do but the force is so weak that we cannot feel it. But if you jump, the earth immediately pulls you down. You can feel the pull, can't you?"



Your weight on the earth is 30 kg. That means the earth pulls you with a force of 30 kg weight or 300 Newton.

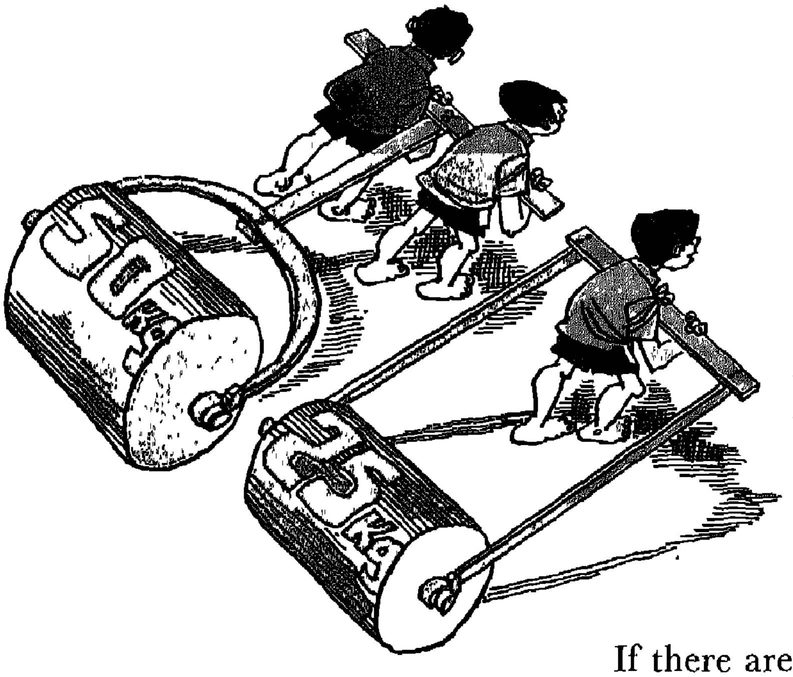
If you were to go to the moon, your weight would be 5kg. Since the moon is smaller than the earth, it pulls with less force.

The force of gravity decreases the farther we go from the earth.

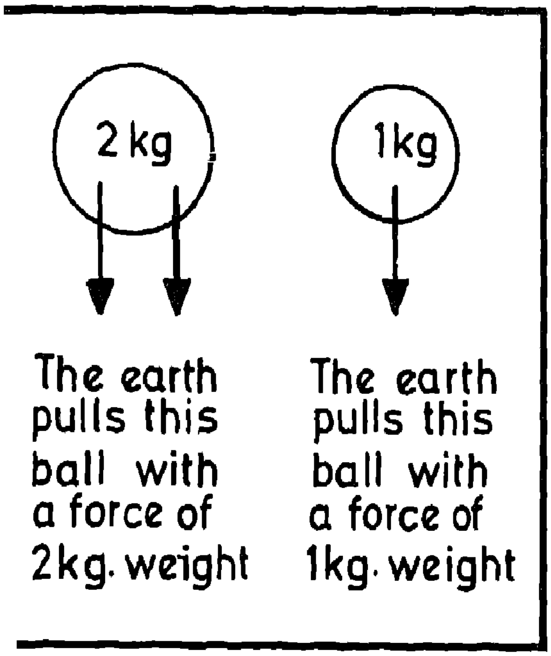


Your weight will change as you travel from one planet to another.

But the mass or the matter that you are made of, does not change.



If one boy pulls a roller of 25 kg weight and two boys pull a roller of 50 kg weight, won't the rollers move at the same speed? If the boys start at the same point together, they are likely to reach the finishing line together.


2 kg
1kg
The earth pulls this ball with a force of 2kg. weight
The earth pulls this ball with a force of 1kg. weight

If there are two bodies, one of 2 kg and the other of 1 kg mass then the earth pulls the 2 kg mass with a force which is two times the force with which the 1 kg mass is pulled.

So the bodies will move together at the same speed. Since the weights start from rest and always move together, their speeds also change at the same rate.

They have the same acceleration.

To accelerate means to increase speed. "Acceleration" tells you how fast the speed increases. If you ride a bicycle alone you can quickly pick up speed or have greater acceleration. If your friend sits on the carrier you cannot pick up speed quite so fast. Can you?

Raja was listening to his father in rapt attention when his mother called them for dinner.

"Listen to this poem before we go for dinner. You may not understand all of it now. But try to learn it by heart. It may be useful someday," father said and began to recite.

You should know of course,
what is FORCE:
It is mass times acceleration;
while force times speed
is POWER indeed,
you need more of it
the faster you run.
If you take for instance,
Force times distance -
it is ENERGY or WORK DONE.

ISAAC NEWTON

Isaac Newton was born in Woolsthorpe, England, on 25 December 1642. His father died before he was born. Newton was brought up by his grandmother on a farm. He entered the Trinity College of Cambridge University at the age of 18. He did well there inspite of being preoccupied with his own projects like studying the sky at night. It so happened that the University was shut down for 18 months because of an outbreak of bubonic plague. Newton spent that time on the farm at Woolsthorpe thinking and reading and it was during this time that Newton made some of his greatest discoveries. He developed Calculus, independent of the German mathematician, Leibniz. Newton discovered and used Calculus to develop his theory of gravitation. All branches of science today depend on Calculus. Newton showed that white light is made of seven colours which can be recombined to give white light. At the age of 26, Newton was made Professor of mathematics at Cambridge. Newton wrote a book called PRINCIPIA and his friend and the great astronomer, Halley (who discovered the famous comet), paid for its publication. Newton was made the President of the Royal Society.

Newton was one of the greatest scientists the world has ever produced. He left his mark in almost every branch of physics and mathematics. Newton died in London on March 20, 1727, at the age of 84.

Potential energy Kinetic energy

Raja was in school.

Miss Leela said, "I shall tell you about gravitational energy today

You know that the earth pulls everything towards it. The weight of an object is the force with which gravity pulls it. Now tell me Bipin, how would you like it if a guava fell on your head?"

"That would be very nice, Miss," Bipin said.

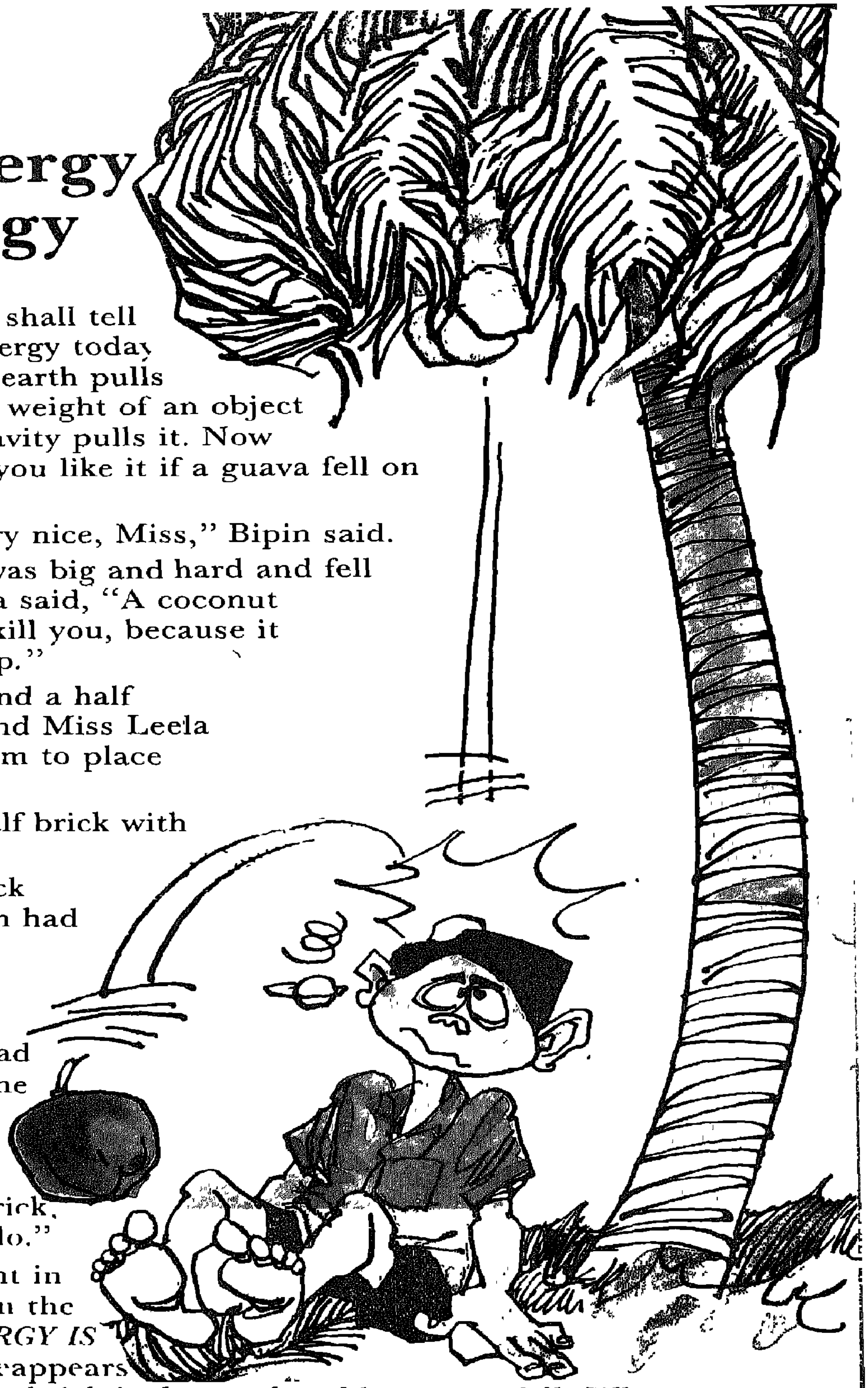
"Not if the guava was big and hard and fell from a height," Miss Leela said, "A coconut falling on your head may kill you, because it is heavy and hangs high up."

There were three and a half bricks lying on the floor and Miss Leela called Harun and asked him to place the bricks on the table.

Harun lifted the half brick with ease.

Lifting one full brick needed more effort. Harun had difficulty lifting two bricks together to place them on the table.

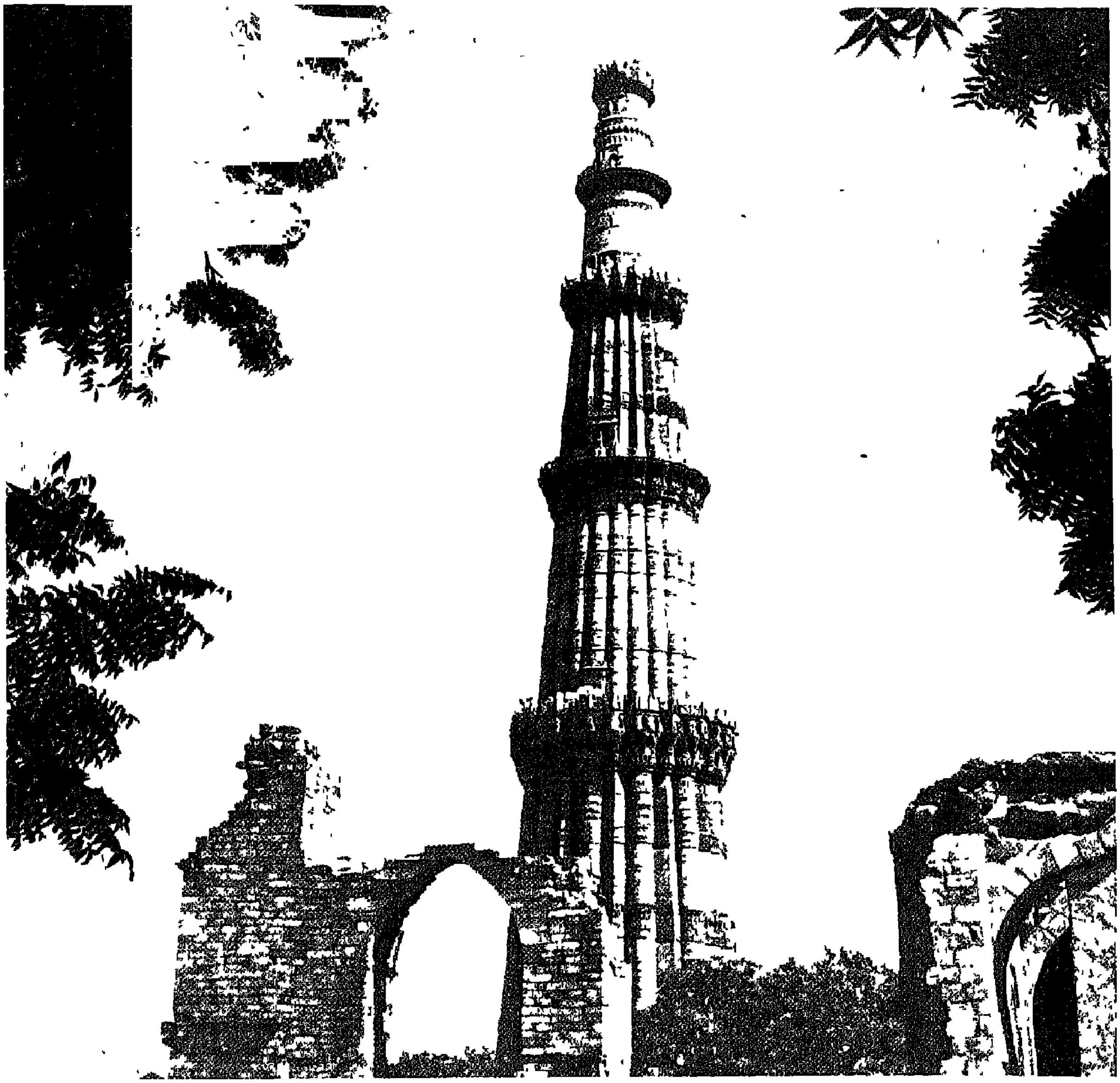
"You see, Harun had to work against gravity. The greater the weight, the more he had to work," Miss Leela said, "The higher he has to lift the brick, the more work he has to do."



The energy he spent in doing the work is stored in the bricks. *THE STORED ENERGY IS POTENTIAL ENERGY.* It reappears as *KINETIC ENERGY* if the brick is dropped and begins to fall. When the brick crashes on the floor, it damages the floor and sound is produced. The brick comes to a stable state on the floor having given up the energy stored in it.

Miss Leela then went to the board and wrote:

THE WORK YOU DO TO LIFT WITH MIGHT
IS STORED AS ENERGY AS THE WEIGHT TIMES HEIGHT

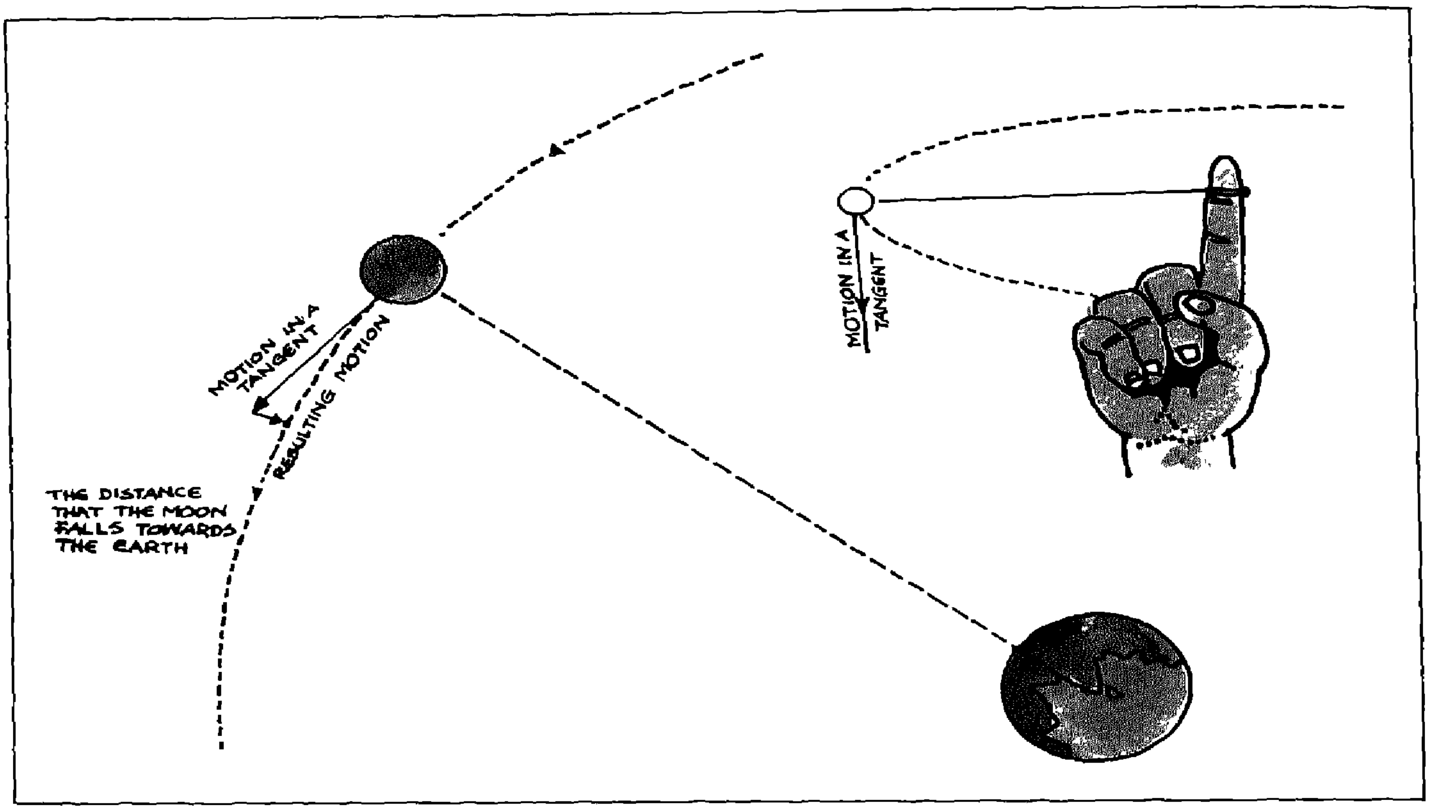


The Qutb Minar at Delhi

The energy that was spent by the masons about 800 years ago, is still stored as potential energy in the stones of the Qutb Minar.

Qutbuddin Aibak, a Sultan of Delhi, began work on the Qutb Minar in 1199. He intended this to be a tower of victory and also as the Minar from where the muazzim could call the faithful to prayer.

The Qutb Minar is 238 feet (73 meters) high and rises to five stories and is made of sand stone. The fourth story was added by Illtutmish, the successor of Qutbuddin. The Minar was damaged twice by lightning in 1326 and in 1368. Firoz Tughluq rebuilt the fourth story and added the fifth after the second disaster. The Minar stood as a symbol of Truth (qutb), Justice and Righteousness.



Wave energy

"Miss, why doesn't the moon fall into the earth and the earth fall into the Sun since they attract each other?" Sudha asked.

"That is a good question Sudha," Miss Leela said.

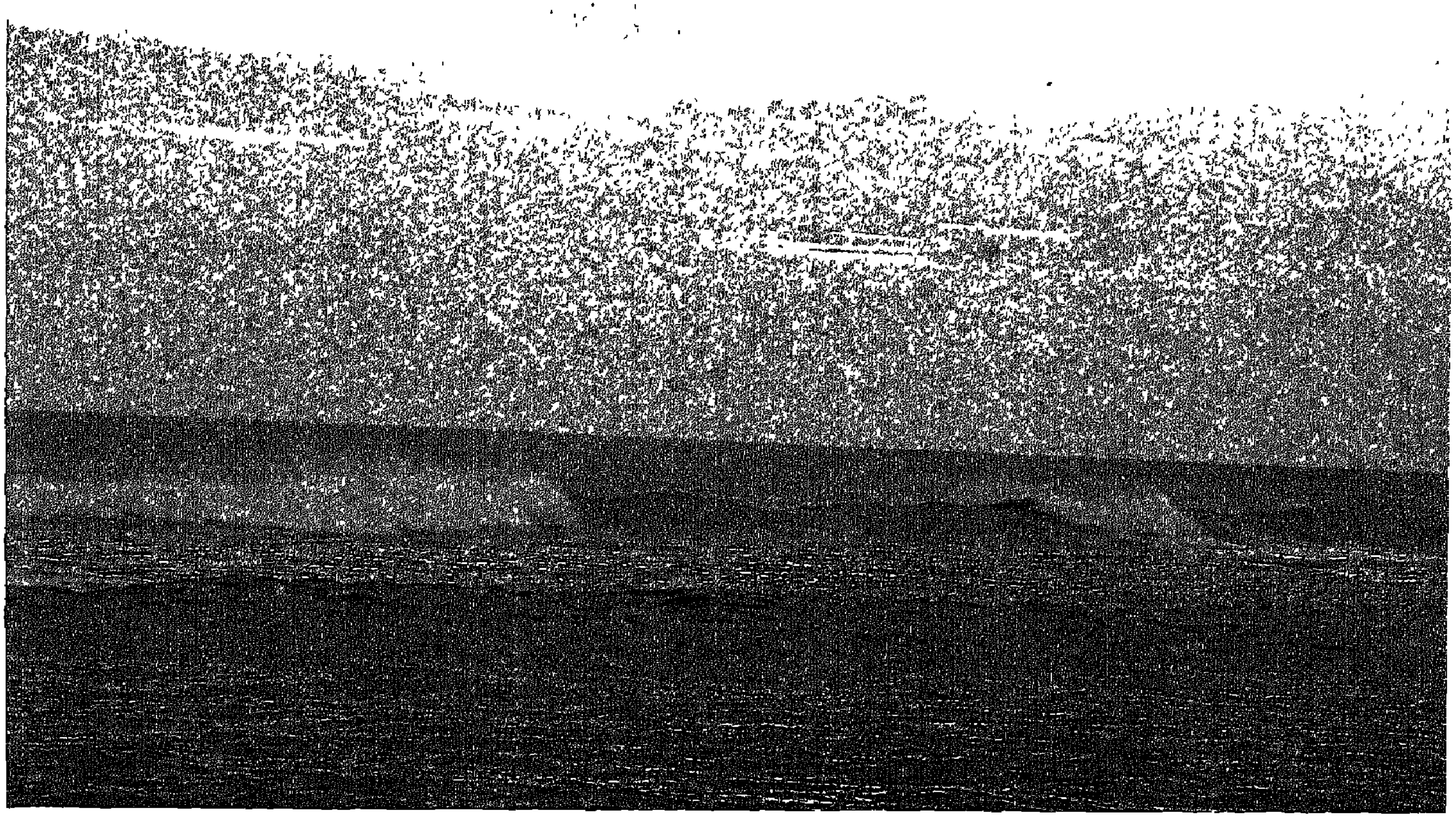
"Take the case of the moon. It really has two movements, one towards the earth and the other at a tangent to it. See this drawing and you will know what I mean by the word 'tangent'. As a result of these two motions, the moon goes round the earth and does not fall into it.

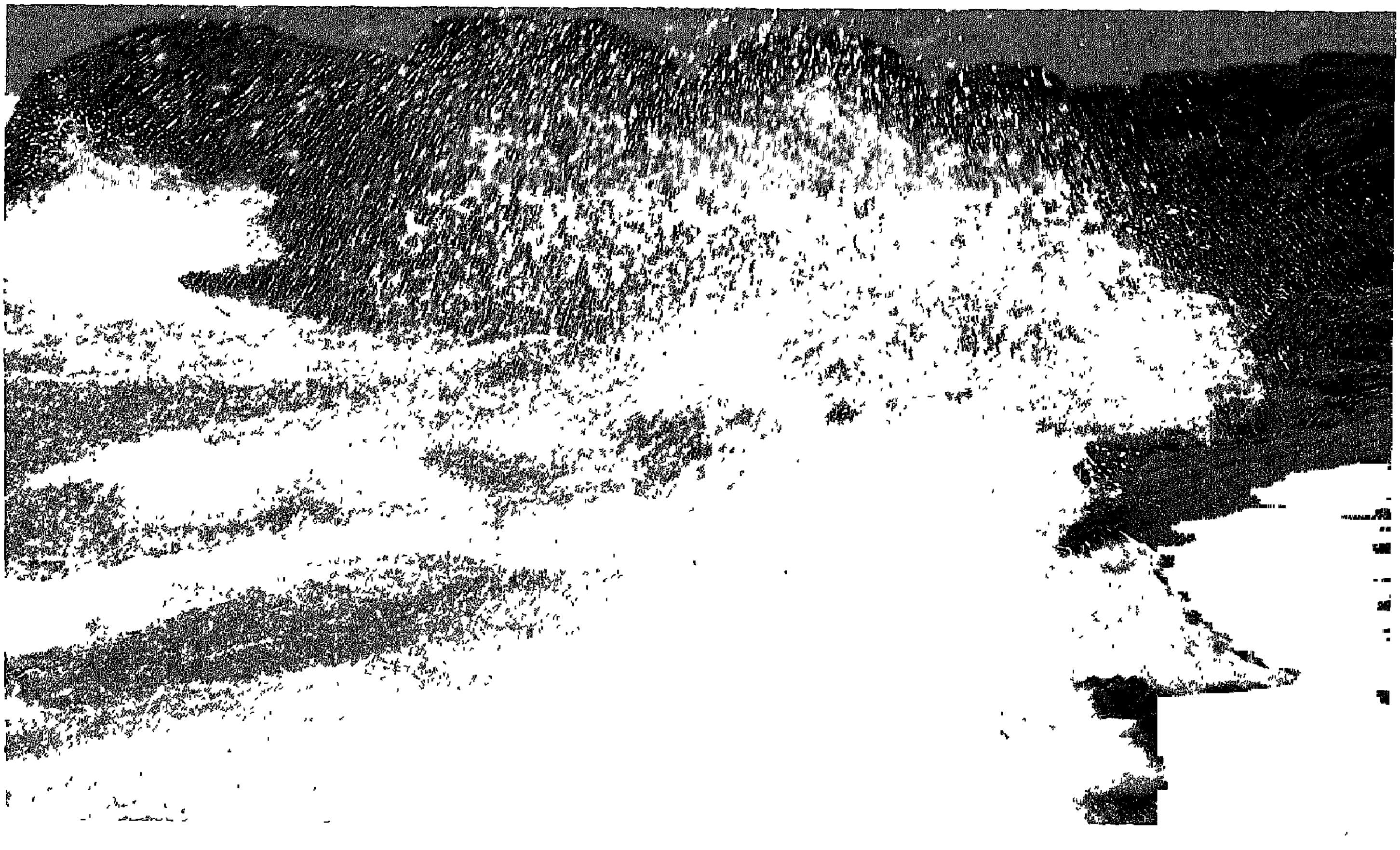
Look at it this way. If you tie a stone with a string, hold one end and jerk the stone into motion, it will go round and round. The pull on the string is like the pull of gravity. If you cut the string, the stone will fly away at a tangent.

On the other hand if the motion at a tangent were to stop, the stone would move towards your finger and hang there.

In a similar way, the moon is continually moving towards the earth under gravity. But it cannot fall into the earth because of its motion at a tangent. So the moon keeps going round the earth. The same thing is true about the earth's motion around the Sun.

The moon and the earth pull each other from a distance. It is the pull of gravity. As a result of this pull, water in the oceans on the earth swells up and tides are formed. Big waves are raised and these waves move with tremendous force. The energy of the tides comes from gravity. Big waves are also caused by strong winds."





The bell rang and it was time to go home. Raja took his bag and started off. He normally took a short-cut through the forest to reach home which was near the railway lines. Raja had just entered the forest when Sthula appeared. Sthula knelt down and asked Raja to climb on his back. Raja loved a ride on Sthula's back when he was hungry and tired.

"You know Sthula", Raja said as soon as he had settled on Sthula's back and the elephant had begun to walk, "Today our science teacher told us about gravity."

"What is that?" Sthula asked.

"It is the force with which the earth pulls us. If there was no gravity we would float as clouds," Raja said.

"Is that true? That would be fun. I haven't seen gravity, have you?" Sthula asked.

"You can't see gravity. It's a force. You can only see and feel its effects," shouted Markata who was sitting on the branch of a tree under which Sthula was passing. He must have overheard the conversation. Sthula and Raja were a bit startled.

"Hello Vidwan," Raja said. "Hello Raja," said Markata and he jumped on Sthula's back and seated himself next to Raja.

"Did you feel the weight Sthula when I fell on you?" asked Markata.

"I felt nothing," said Sthula. "Besides, you did not fall. You jumped on to my back."

"No, I just let myself go and the earth pulled me down with a force equal to my weight. Had I been heavier, you would have felt the force all right. If you fell on someone, he would be crushed to death," Markata said.

"If you are being rude, you better get off my back," Sthula said angrily. Raja was worried lest Markata and Sthula should start quarrelling. He intervened and said, "Wouldn't it be great fun if there was no gravity?"

"Not really," said Markata, "if there was no gravity and I had jumped as I often do, I would keep going up and up and never return to the earth, I wouldn't like that."

"Although I am not given to jumping about as some are," said Sthula, "what would happen if I were to jump?"

"That's a good question," Markata said, "since you are big, you might not fly off as I would. Air would resist your motion and you would possibly float as a cloud."

Sthula was very pleased with this prospect. "But how would Sthula come down if he wanted to?" Raja asked.

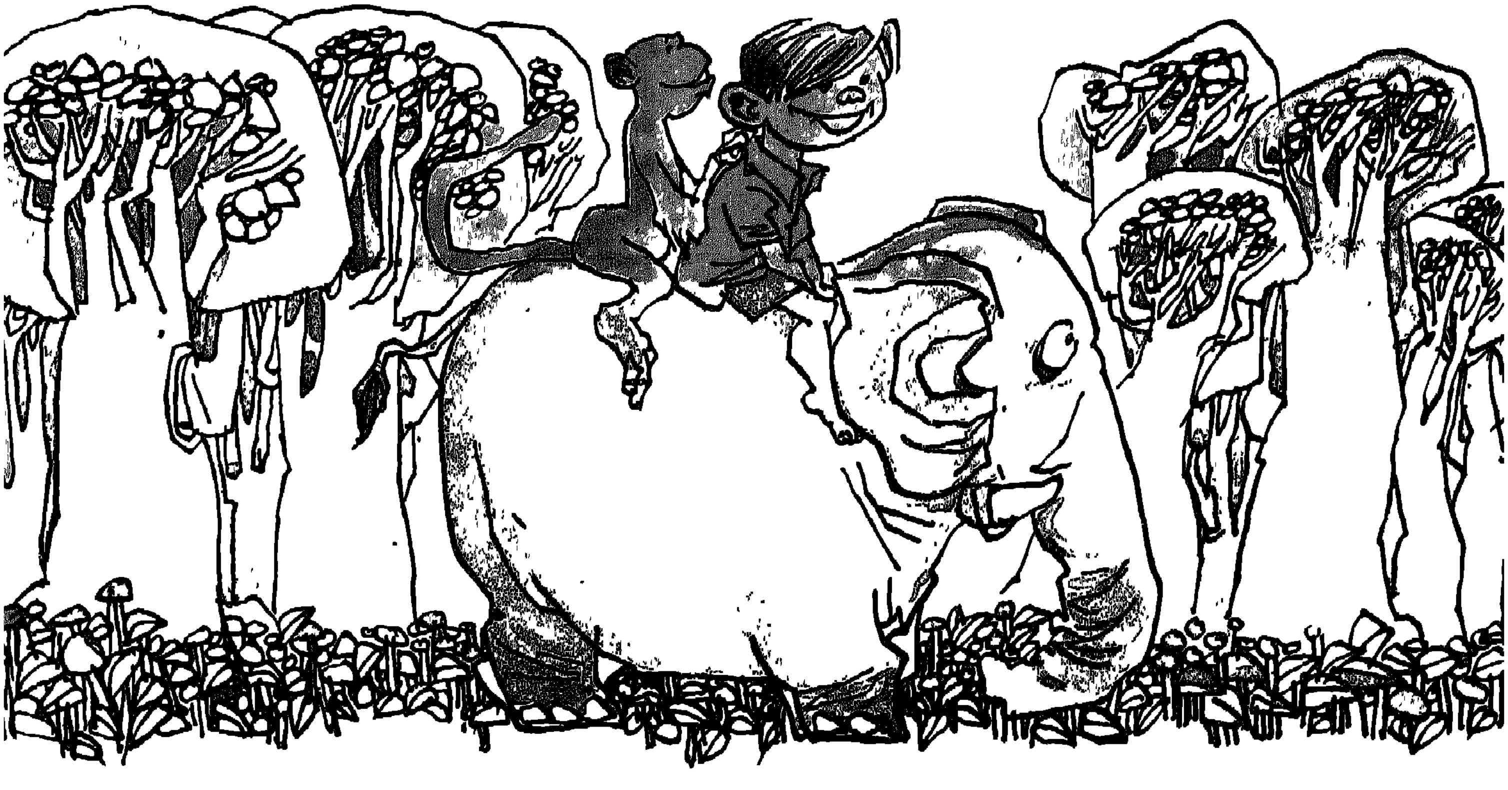
Vidwan thought for a while and then brightened up. "Why? All that Sthula would have to do would be to point his trunk upwards and blow hard. He could then come down. If he wanted to move forward, he would need to bend his trunk and blow backward. That is how a jet plane flies, you know."

"Could I fly like a jet plane, Vidwan?" Sthula asked, obviously very pleased.

"Yes, you could, I suppose. Of course you would have to blow very hard to move fast. But because you can twist and turn your trunk, you could move in all directions. That is how rockets change their direction by firing jets."

Sthula was flattered. He began to dream that one of these days if this thing called gravity could be removed, he could float around like a cloud and travel wherever he wanted to by simply blowing through his trunk. Markata interrupted his dream by saying, "But let me tell you something. If gravity disappears there will be no force to hold the earth together. It will break up into dust and we would all disappear. In fact, had there been no gravity, the stars and the planets would not even have formed."

Sthula was greatly disappointed. So was Raja. Markata tried to cheer them up. "Hey, let's all go to the moon. The gravitational pull of the moon is about one sixth of earth's gravity. Our weights will become one sixth of what our weights are here on the earth. And Raja you could jump across a two storeyed building without any difficulty. Wouldn't that be great?"



On the moon

"But father said there is no air on the moon because the gravity is too weak and all the air spilled off. How can we live on the moon, Vidwan?"

"Wear masks and space-suits like the astronauts do," Markata said.

"You can do that," Sthula said, "I am happy here on earth with its gravity and everything else it has."

Sthula had nearly reached the edge of the forest. Raja jumped off as Sthula knelt down. He said goodbye and ran towards his house which was quite near. Raja could see his mother waiting for him on the verandah.

Coming home from school was a lovely feeling for Raja. Mother kept food ready. His sister Prabha would sometimes be back from college before him. Raja loved a dosa or a paratha. He disliked milk. Raja said: "You know Ma, if we eat meat or drink milk, we receive the Sun's energy not second hand but third hand."

"Whoever told you that?" mother asked.

Raja was about to tell his mother what Markata had told Pashuraj, but he stopped short as Prabha was standing nearby.

"Maybe the Sun told him," Prabha said sarcastically. "You know Ma, Raja talks with trees and cats and ...." Raja was furious. He was about to pounce on Prabha but mother intervened, "Stop teasing him, Prabha Don't you know that plants and trees also have life? They respond to pain. Acharya Jagadish Chandra Bose has shown this." Raja felt grateful to his mother. He quickly finished his food and ran out of the kitchen. Prabha laughed and tried to catch him. But Raja was too quick for her.

Raja went to Keshav's house next door and they both went to the playground. As they approached the group of boys standing in the playground, Samuel, one of the older boys from their school told Keshav, "Come on Mr. Inertia, let's have a game."

"My name is Keshav and not Inertia," Keshav said angrily.

"I know, but according to Isaac Newton, you are Inertia because you are lazy and you continue in the state of rest unless forced to move," Samuel said nastily. Samuel's classmate, Abdul said, "In that case he should continue to move, if he is not forced to stop. Newton said that too. And his law applies to things and not to Keshav."

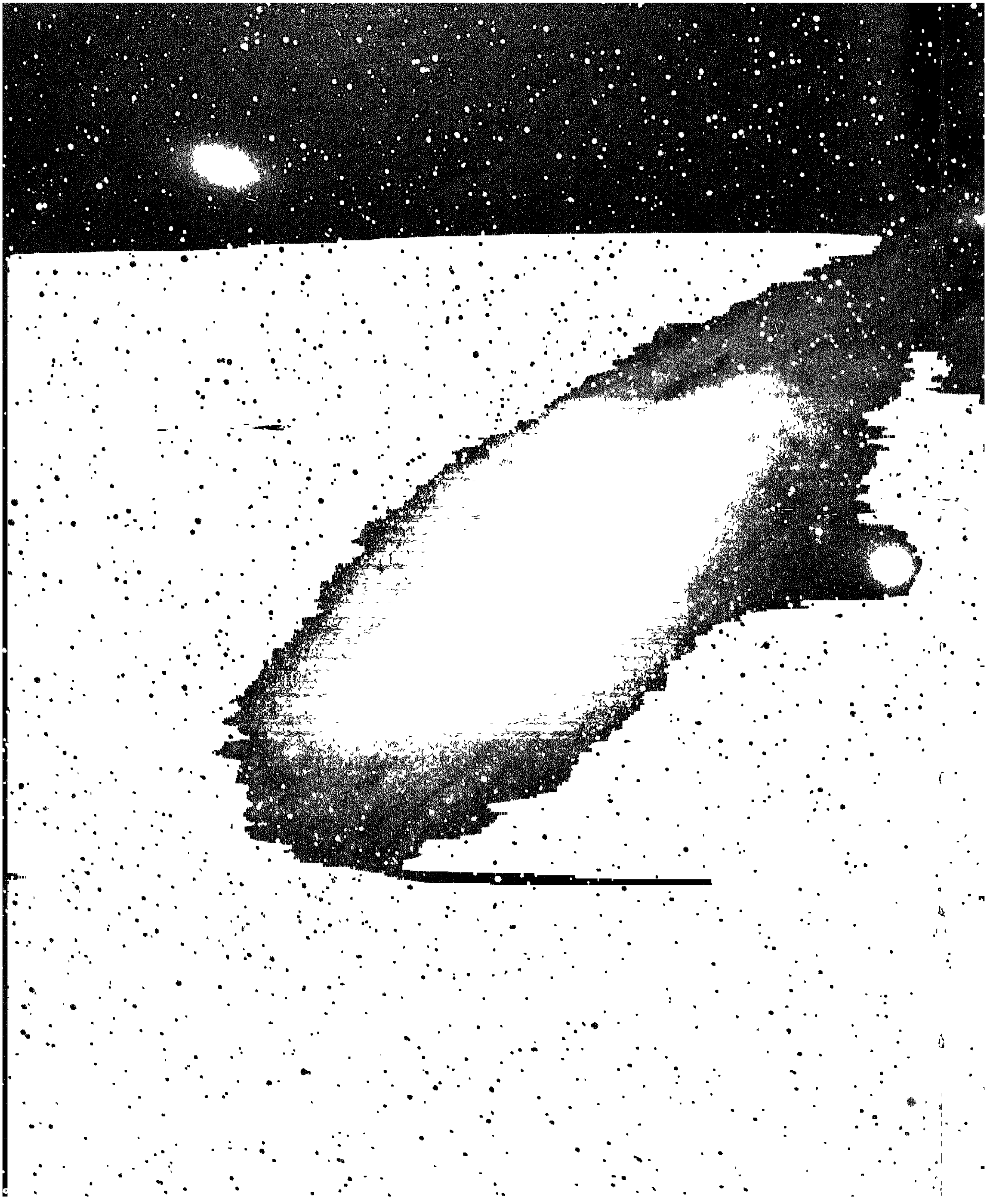
"I was joking," Samuel said.

"I don't like your jokes," said Keshav.

Raja could understand that their football would not move but stay still unless kicked. But he could not imagine that the ball would continue to move unless it was forced to stop. Surely that was not true! He rolled the ball on the ground and told Abdul, "Look the ball stopped on its own."

"The ball stopped because the ground is rough and FRICTION forced it to stop," Abdul said.

"Anyway let us have a game now," and off they went.



How much is a billion?

Raja returned from the playground at 6 p.m., washed and went to his study. It was nearly 8 o'clock now. Raja quietly left his seat and went to the terrace. Usually the Owl came there once a week.

"Sorry, if I kept you waiting," Raja said.

"I came just now. How are you?" Owl asked.

"Very well thank you," Raja said "You know, Owl, Miss Leela told us that of all the energy we receive from the Sun, half is heat and half is light.

Where does the Sun get all its energy from, I wonder."

"That," the Owl said, "is a good question. Look at the sky. Although we can see only a few thousands stars, there are billions and billions of them. And think that our Sun which gives almost all our energy is just one of the 100 billion stars in our galaxy which is called the Milky Way and there are 10 billion such galaxies in this Universe."

"How much is a billion, Owl?" Raja asked.

"One thousand million that means a thousand, thousand, thousand."

"But you did not tell me where the Sun gets its energy from."

"Well, I am not very sure myself. I believe it has something to do with all the Hydrogen present in the sun. The nuclei of Hydrogen atoms fuse in a certain way and produce intense heat.

Every second, the Sun gives out as much heat as three million billion billion burning matches. Write 24 zeros after 3 and you get the number," Owl said.

"I cannot think of such numbers, Owl,can you?"

"It is difficult, but think of it this way. Try counting numbers and you will find that it takes you about one minute to count upto 150. If you keep counting at this rate, you can count upto 9000 in one hour. It will take you 12 years to count upto 1 billion, if you count non-stop. Does that make sense Raja?"

"It does now. You know so much Owl," said Raja.

"Not really. I do know that I know very little," Owl said humbly. "Anyway I must be off. See you next week."

This is the great Andromeda galaxy, the nearest comparable to our own galaxy-the MilkyWay. Andromeda is two million light years away from us. It means that light which travels at 300,000 km/second takes 2 million years to travel this distance. Light travels 9,500000,000000 km in a year. So Andromeda is 19,000000,000000,000000 km away from us.

What is an atom?

Raja quietly came down. He was trying to figure out what Owl had told him. Twelve years to count up to one billion! And there are a billion billion stars! And our Earth is just a tiny planet of one such star! On the other hand a drop of water is made of millions of atoms, father had once told him.

Mother had served dinner Raja ate quietly.

"You are very quiet tonight Raja, aren't you?" father asked.

"How many atoms are there in this grain of rice father?" Raja asked in reply. "I really cannot say. Millions, I suppose. It would be made mostly of carbon atoms which make complex molecules. I cannot explain everything now I shall bring a few charts from our library tomorrow. You better eat your dinner now," father said.

Father brought a few nice charts as he had promised. Prabha and Raja spread them on the verandah to have a look at them.

Nearly 2500 years ago a Greek philosopher called Democritus guessed that things are made of countless very small particles which he called ATOMOS.

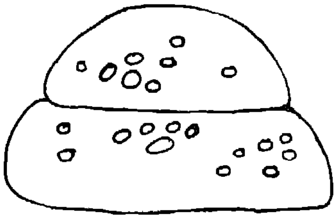
Even before Democritus, an Indian philosopher, called Kanad, also believed that things were made of Kana or tiny particles. It is said that other philosophers disagreed and they teasingly called him Kanad or Atom-eater.

If you arrange 100 million hydrogen atoms in one line it would only be an inch long.

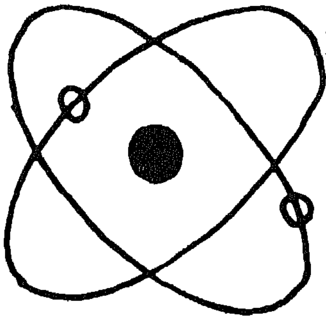
See how many dots you can place side by side within one inch If you take a fine pencil you may put at the most 50 dots. So you can arrange 2 million hydrogen atoms side by side across the diameter of a dot.

John Dalton (1766-1844)-son of an English weaver, transformed the vague ideas about atoms into an atomic theory and explained chemical reactions in terms of combinations of atoms.

1897 Atoms were thought to be the smallest elements that constituted matter. J. J. Thompson succeeded in tearing much smaller elements (which he called corpuscles) from atoms. These corpuscles were later called ELECTRONS. Electrons have electric charge: weight: 1/1834 of a Hydrogen atom. An electron is said to have NEGATIVE charge. Since an atom is electrically neutral, there must be POSITIVE charge some where inside it.



1906 Thompson thought that an atom is like a cake. The body is made of positive charge and the negative charges are studded like raisins on the cake.



But surely an atom cannot have the positive and negative charges lying side by side. The charges would destroy each other. Isn't + 5 − 5 = 0 ?

1911 Ernest Rutherford, a NewZealander settled in England, concluded from some experiments that most of the mass of an atom is at its centre and has positive electric charge.

The inside of an atom is mostly empty space. Electrons orbit a nucleus like planets orbit the Sun. An atom is almost like the solar system.

1913 Niels Bohr, a young Danish physicist, modified the atomic model of Rutherford.

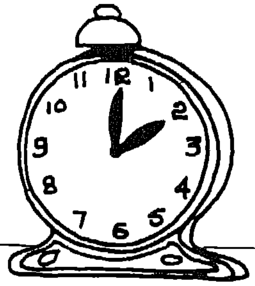
An atom is not exactly like a solar system, he said. Electrons occupy shells that represent definite energy levels.

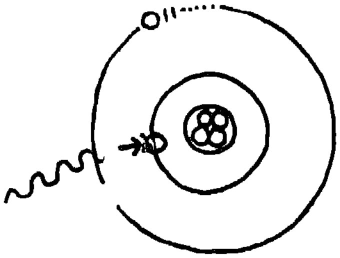
If an electron receives energy from outside, it jumps from an inner to an outer shell. When an electron jumps from an outer to an inner shell, it gives out energy.

1932 The nucleus of an atom usually has twice the mass of PROTONS which carry positive charge. What else is there in the nucleus?

Chadwick discovered Neutrons which have the same mass as the protons but have no electric charge. Neutrons and Protons are tightly packed in the nucleus.

Later discoveries have shown that the nucleus has other particles and that there is a fuzzy distribution of electrons around the nucleus. ButBohr's model is adequate for our purposes.





Have you seen clocks or watches in which the hands glow at night? They have a special paint. Their atoms absorb light energy from sunlight and the electrons jump to outer shells.

At night the electrons keep jumping back emiting packets of energy or PHOTONS. Light is made of photons that is how the hands and the hours of the clock may be seen in the dark.

What is light?

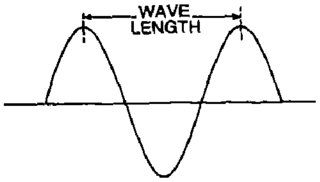
Light is a form of ENERGY.

Sunlight is the mixture of seven colours: VIBGYOR as in a Rainbow. But what is light made of?

"Light is made of waves," said Thomas Young in 1801.

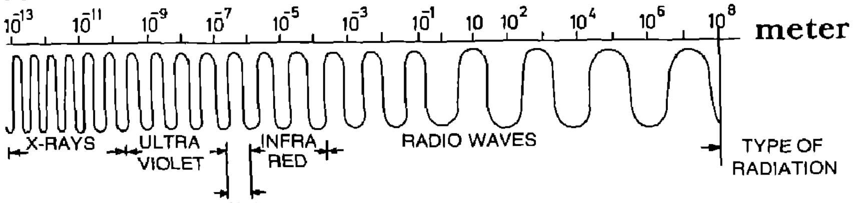
"How dare this young fellow contradict Newton who said that light is made of particles?" said the followers of Sir Isaac Newton.

But Clark Maxwell, a great physicist from Scotland, showed that Light, Heat and many other rays that we cannot see, all belong to the same family and travel as waves.



The distance between two peaks of a wave is the wavelength. Violet has short wavelengths. The wavelength of Red is nearly two times as long. Long waves can travel longer distances through the atmosphere before breaking up. That is why we can see Red light from long distances and it is used as danger signals.

X-Rays that we use to take photographs of our bones, Radio waves which carry pictures and sound for the televisions belong to the same family of Heat and Light waves and they all travel 300,000 kilometres per second.

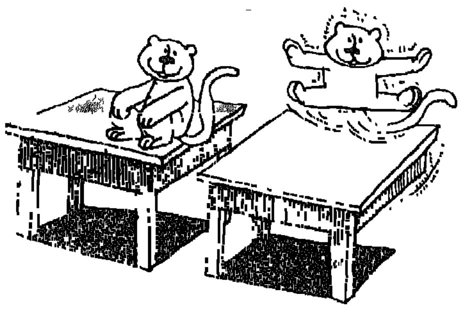


Everyone now believed in the wave theory. But early this century it was found that wave theory could not explain all the behaviours of light.

Max Planck and Albert Einstein showed that Heat and Light are made of packets of Energy. These packets of light energy were called PHOTONS. When electrons jump from outer to inner orbits, Photons are emitted. Photons have more energy when electrons jump long distances in heavy atoms. Violet, ultraviolet and X-Rays are made of high energy photons. Long waves are made of low energy photons.

So who is right after all? Is light made of photons or waves?

It is both. Doesn't water come down as raindrops and also flow as waves in a river? True it does. But is it the same with light? Not quite but this may be taken as a simple analogy.



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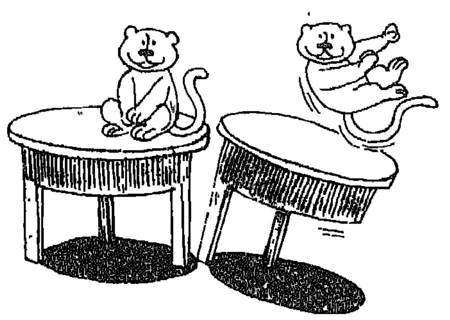

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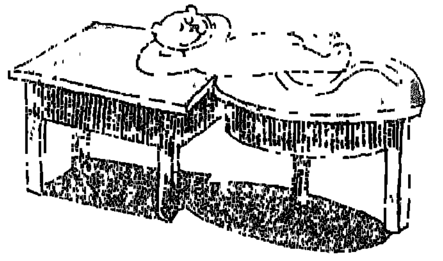
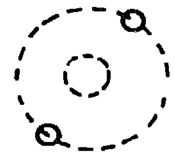
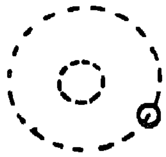


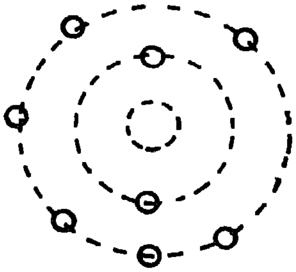
The unstable tables are stable when they are joined.



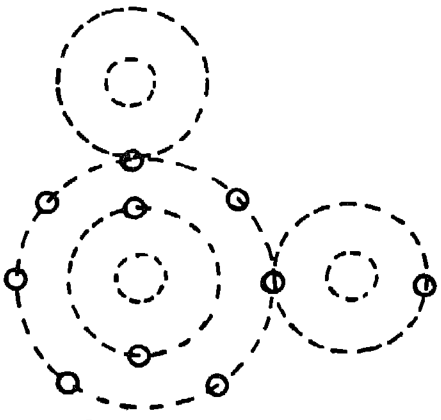
A Helium atom is stable. The first shell of the atom can take 2 electrons. Helium has both.



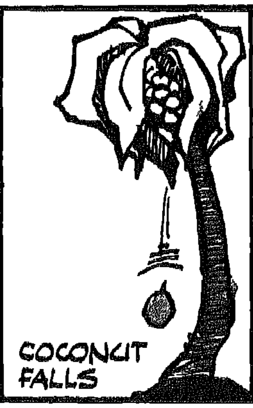
A Hydrogen atom has only one electron instead of two. A Hydrogen atom is not stable.

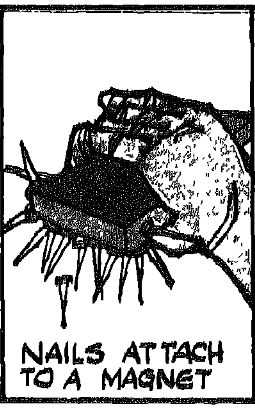


An Oxygen atom is also unstable. Its outer shell can take 8 electrons. It has only 6. So 2 more electrons will make it stable.

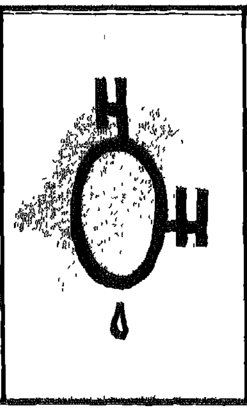


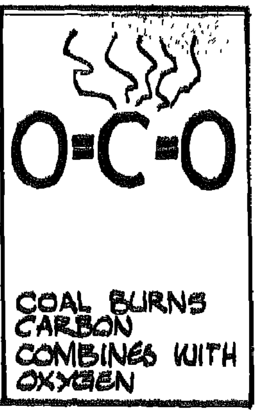
So an Oxygen atom combines with two Hydrogen atoms to fill its outer orbit. The Hydrogen and Oxygen share the two electrons, so a bond is formed. A new chemical compound is produced. IT IS A MOLECULE OF WATER. It is very stable.





NAILS ATTACH TO A MAGNET





O=C=O
COAL BURNS CARBON COMBINES WITH OXYGEN

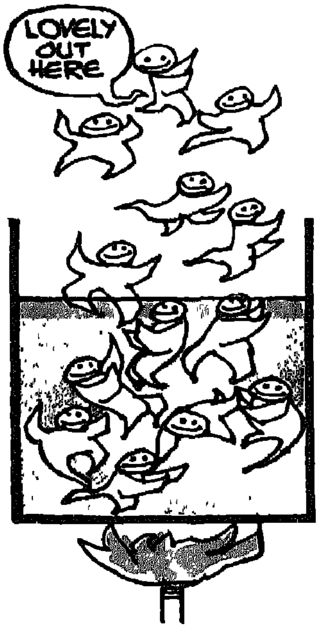
In all these processes energy is released.

How steam is made to work

Take a glass of water. There are billions of molecules in it. The water molecules keep running around. Some of the molecules at the surface escape as vapour.

If you pour this liquid into a saucer, more water molecules will escape because there is more surface to escape from.

Leave a plate with water for a few days. There will be nothing left.

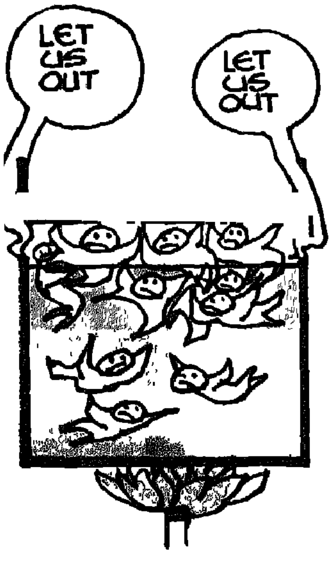


If water is heated, the molecules receive heat energy and run more vigorously.

A much larger number of molecules now escape from the surface.

You can even see them steaming out.

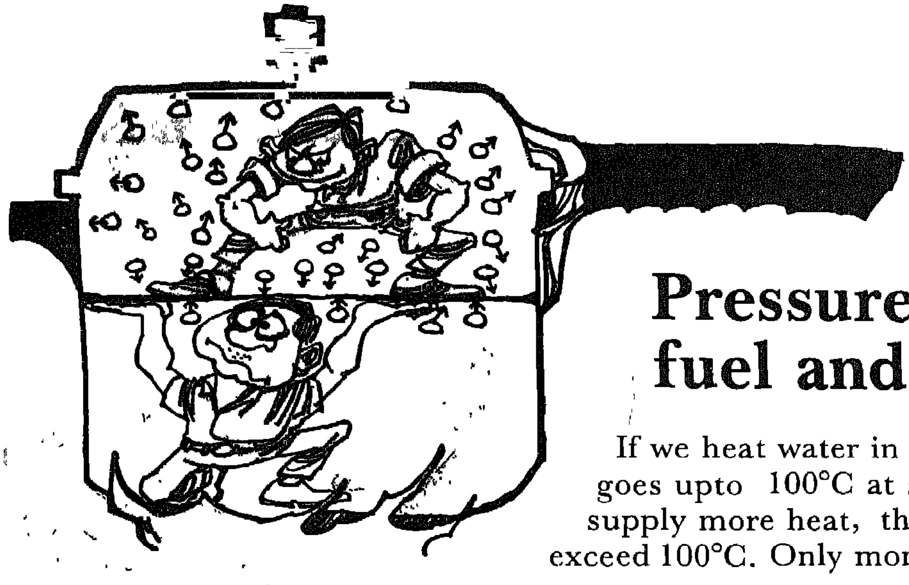
The temperature of the water stays at 100°C, only more and more molecules escape as heat is supplied.



If you put a lid on or apply pressure, the molecules are squeezed and squeezed and cannot escape freely.

They keep hitting the lid and try to push it up. The lid or the piston is forced to move.

HEAT ENERGY IS TURNED INTO MECHANICAL ENERGY.



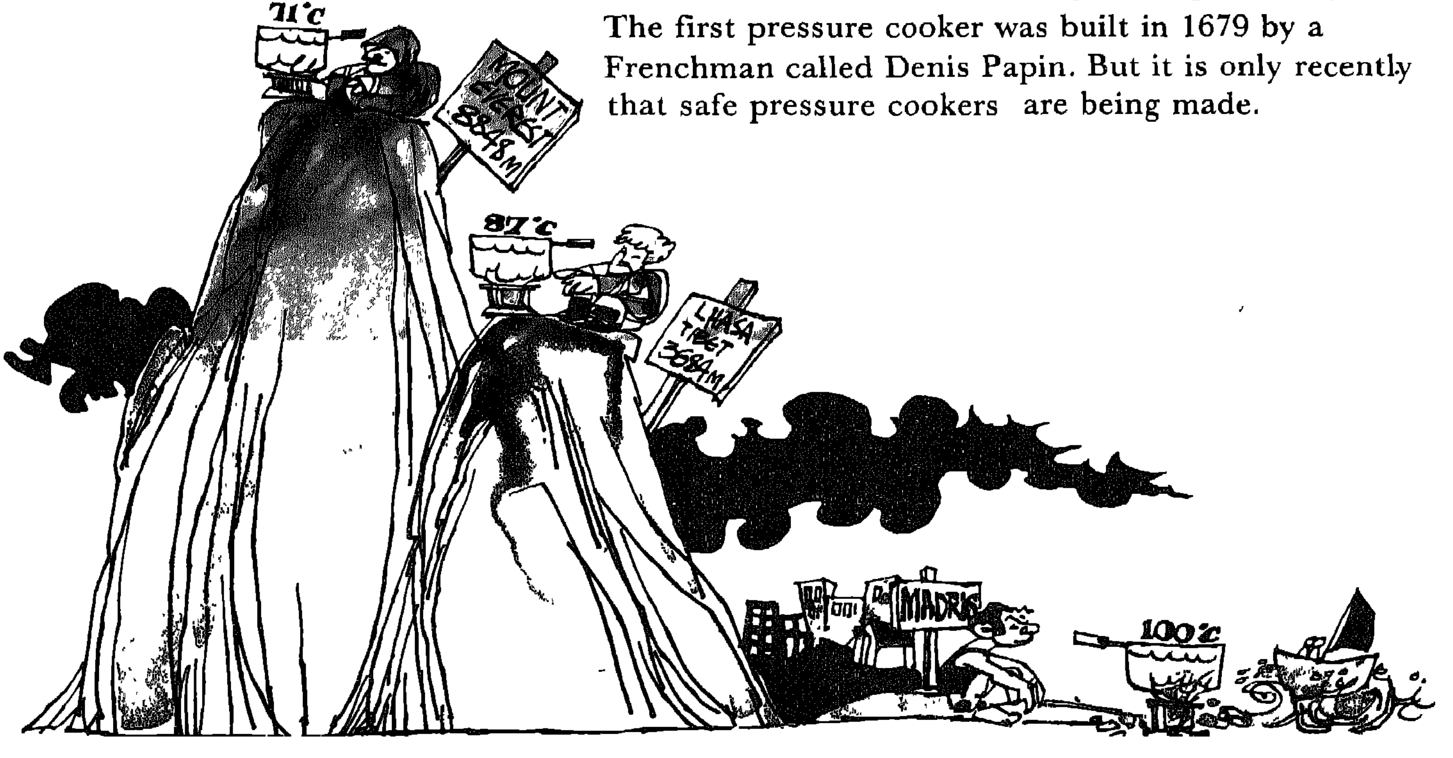
Pressure cookers save fuel and time

If we heat water in an open vessel, its temperature goes upto 100°C at sea level, and even if we supply more heat, the temperature of water will not exceed 100°C. Only more steam is formed.

If the pressure of air above the surface of water is reduced, the molecules can escape more easily and water boils at lower temperatures. As we go up a mountain the atmospheric pressure becomes less and water begins to boil before its temperature reaches 100°C. On Mount Everest water boils at 71°C and food does not cook very well.

In a pressure cooker, steam is not allowed to escape. As the water is heated, more steam fills the empty space and the water molecules keep hitting harder and harder in all directions. The pressure of steam keeps building up. As pressure on the surface of the water goes up, molecules on the water surface find it more difficult to escape as vapour. They get more and more agitated and the water temperature keeps increasing beyond 100°C. As water temperature goes up, food in the water cooks easily and quickly. So, we have to spend much less time and fuel if we use a pressure cooker because we make steam do work instead of letting it escape merrily.

The first pressure cooker was built in 1679 by a Frenchman called Denis Papin. But it is only recently that safe pressure cookers are being made.



How steam engines changed the world

"James Watt was not the inventor of the steam engine," Raja's father told him.

Prabha had just come in with a hot cup of tea. Raja could see the steam coming out of the cup and was amused to think of the millions of water molecules that were escaping from the cup and ending up in father's stomach.

"Who invented steam engines then?" Prabha seemed surprised.

"Well,steam was first used to make toys in 100 AD by a man called Hero who lived in Alexandria," father said,"Steam was put to use many hundred years later around 1700 AD. When James Watt was a child, steam engines were used for pumping water. But these engines were not efficient. There was a type of engine called Newcomen engine. It was so inefficient that someone said about this engine, it took an iron mine to manufacture it and a coal mine to run it."

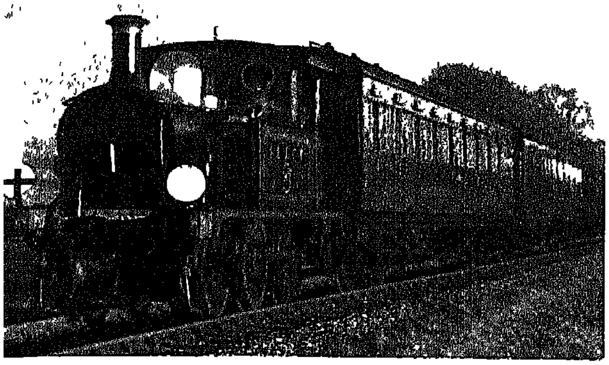
"You see, efficiency is very important for all engines and machines. It tells you how much work you get out of a machine for the amount of energy you put into it. If the machine is more efficient, we get more work out of it for less energy input.

James Watt improved steam engines to a great extent. Steam engines were not only used for trains but they were used in factories for weaving and doing other work.

Steam engines relieved men of hard work and some have said, they started the industrial revolution. Today computers are relieving us of unnecessary mental efforts."

"Why don't they use steam engines for trains these days father?" Prabha asked.

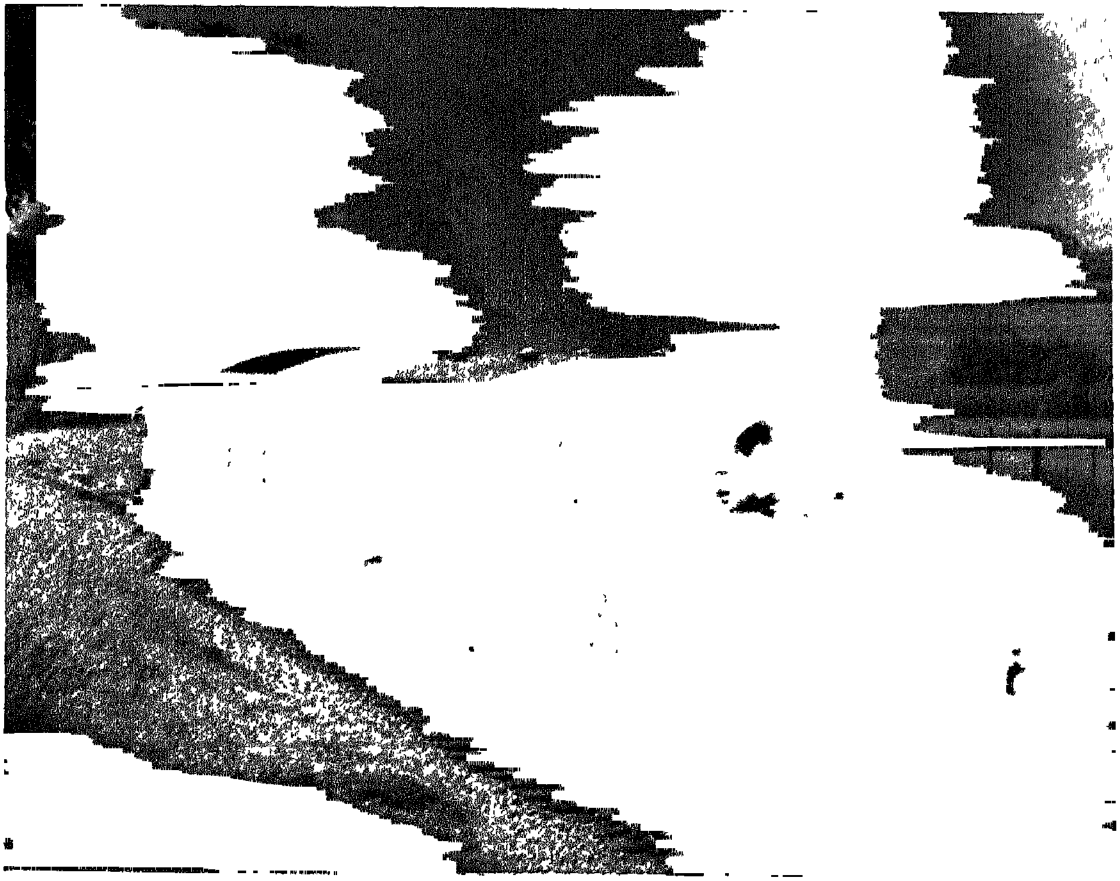
"Well, steam engines generally are not efficient and they pollute the atmosphere. I remember how we used to be covered with coal dust when we travelled by train when we were your age. Now a large number of engines use diesel oil and at some places electric engines haul trains. Electric trains are very efficient and clean, you see."



In 1852 Frederick Sleigh Roberts, a British Officer reached Calcutta. He had been posted at Peshawar 2100 km away. Lieutenant Roberts travelled in a barge pulled by a steamer up the Ganga and reached Varanasi. From there he went to Meerut in a 'horse dak' (mail coach). Finally he was carried 1000 km in a 'doli'. It took him 3 months to reach Peshawar. Today you can cover the same distance by train in about 30 hours. Travelling was not only difficult in those days but also hazardous. People travelled long distances only when they had to.

The first Indian train steamed off from Bombay in 1853. The East Indian Railway started next year. This was followed by Madras Railway in 1856.

Nearly 62,000 km of track has been laid since then. Everyday more than ten million passengers travel by trains in India. About 11,000 locomotives keep running up and down the tracks. Diesel engines and electric locomotives have almost replaced steam engines now. A beautiful underground Railway in Calcutta called the 'Metro' carries thousands of passengers up and down everyday.



Can work be turned into heat?

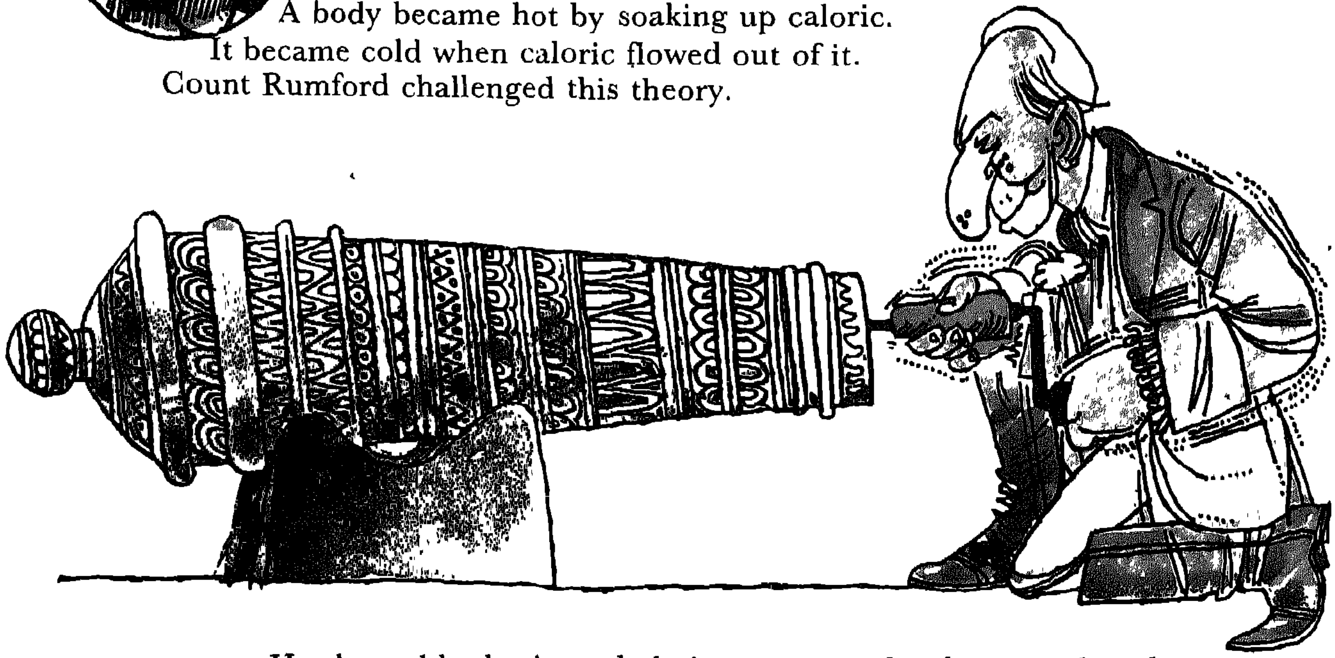
"Can mechanical work produce heat?" Raja asked.

"Of course it can. Rub your hands. You are doing mechanical work. Don't your palms feel hot? Heat is being produced by friction. When you inflate a football with a pump, you will notice that the pump becomes hot. Do you know why?" father asked.

"Is it due to friction?" Raja was not very sure.

"Not entirely. As soon as you push the piston down, the air in the pump is compressed. The air molecules are brought closer together. If we heat air, the molecules absorb heat energy and fly apart or the air expands. If on the other hand we force air molecules to come close, the air contracts and the molecules give up some energy as heat and that is why the pump becomes hot."

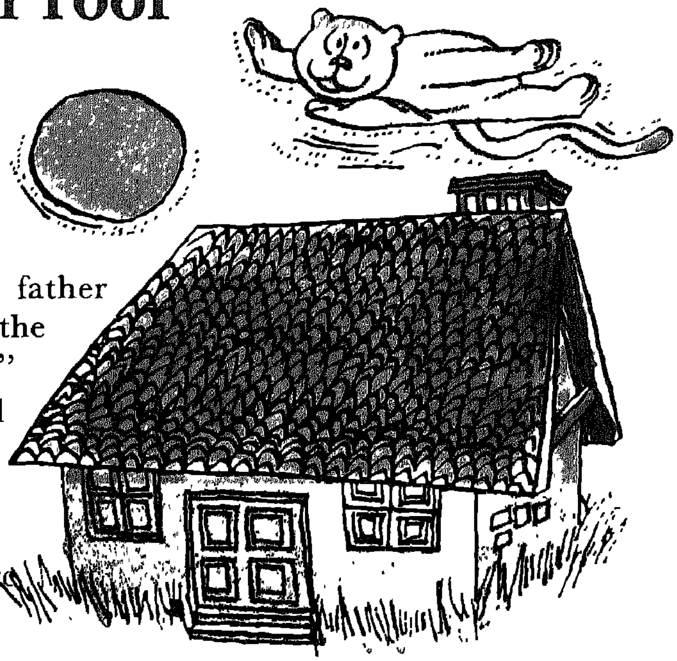
For a long time scientists thought that HEAT was a weightless fluid called caloric which we cannot see. A body became hot by soaking up caloric. It became cold when caloric flowed out of it. Count Rumford challenged this theory.



He showed by boring a hole in a cannon that heat produced that way could even boil water. Heat was produced as long as the drill was rotated. Heat, he said, came from the inner motion of substances.

Now we know that heat is due to the movement of atoms and molecules in a substance.

A cat on a hot tin roof



“Here is a riddle for you,” father told Raja. “Which is the cooler of the two, this book or this steel plate?”

Raja touched the book and then the steel plate. “The steel plate is cooler,” Raja said.

“Wrong,” father said. “They are both at room temperature which is now less than your body temperature.

Since the steel plate is made of metal, it quickly absorbs heat from your body and you think it is cold. If the room temperature was higher than your body temperature, you would have said that the steel plate is hotter than the book.”

“Tell me father, doesn’t all the water in the oceans contain a very large amount of heat? Why can’t we make use of this energy?” Prabha asked.

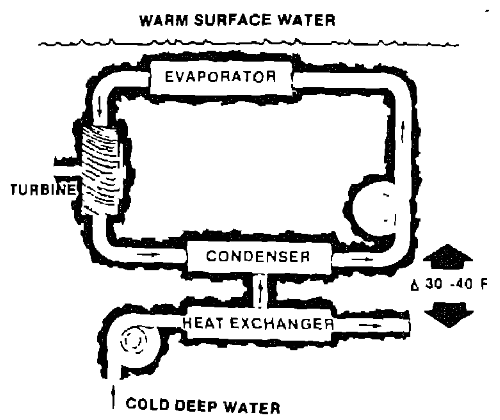
“Heat can flow only from high temperature to low temperature like water flows from a higher to a lower level.”

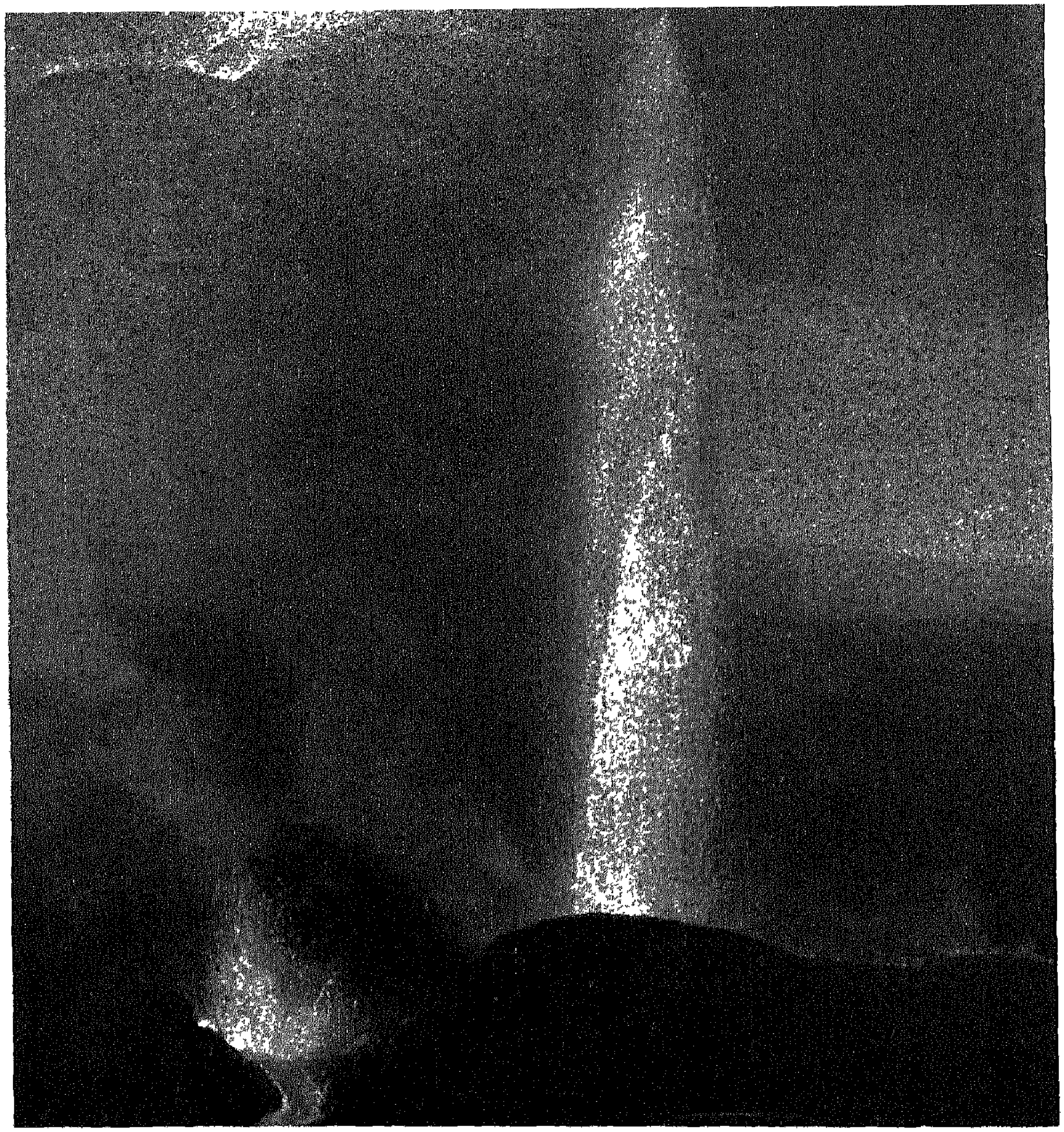
As rivers flow into the oceans, so heat usually flows into the oceans and not out of it because sea water is never hot.

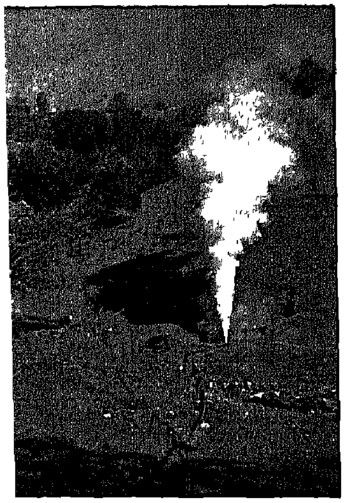
Mind you, the temperature of water within the sea is not the same everywhere. It gets cooler as you go down. Scientists and engineers are trying to draw energy from the sea by using this difference in temperature with the depth.

The heat contained in a needle, which is red hot, is less than the heat contained in a cup of water at room temperature. Dip the needle in the water and the needle becomes cold, which means that heat flowed from the needle to the water in the cup.”

OCEAN Δ, POWER PLANT







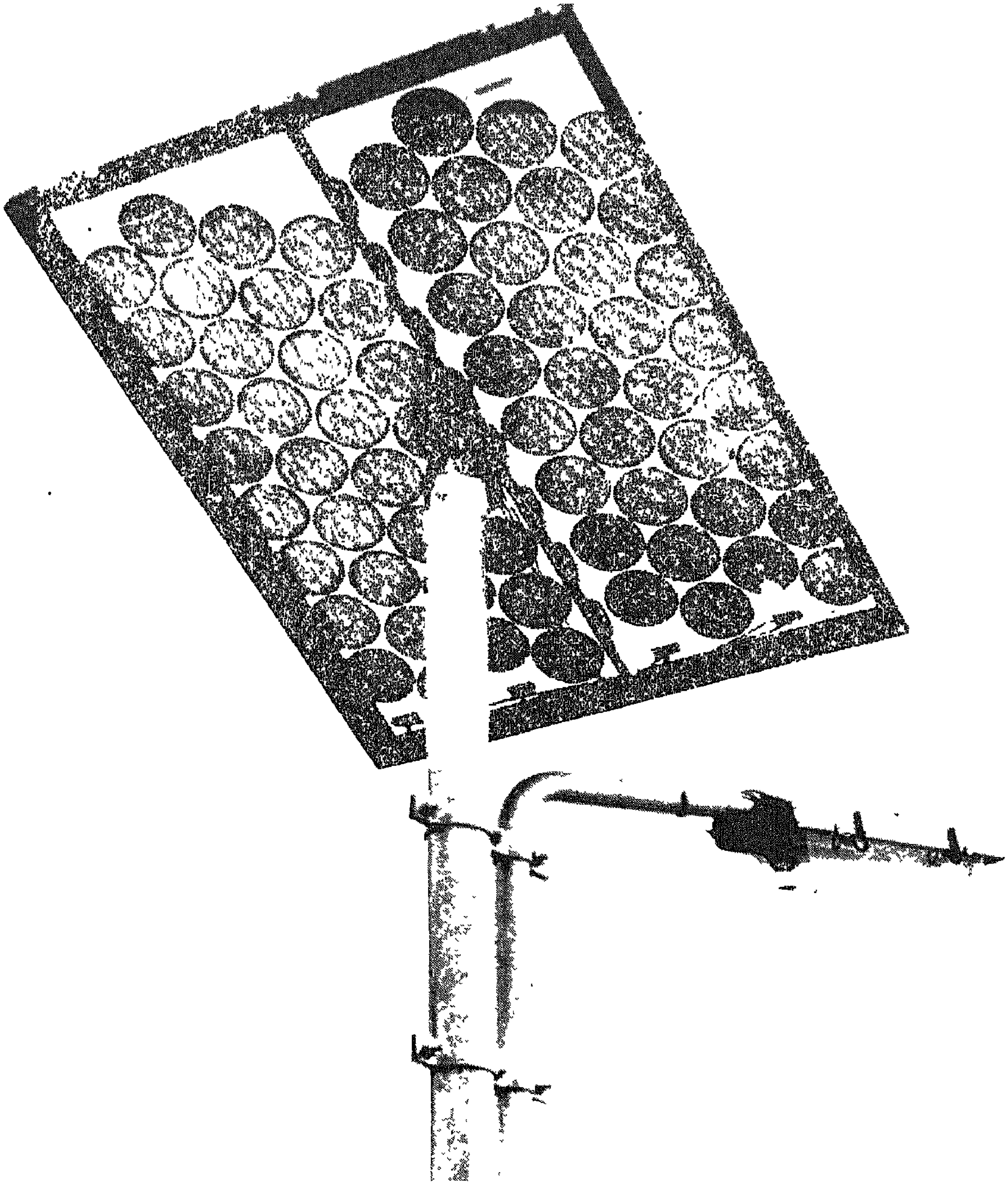
Volcanoes and geysers

"Isn't there a lot of heat inside the earth, father? Why can't we use that heat?" Prabha persisted.

"You are right, Prabha. The inside of the earth is so hot that everything melts there. Even stone melts. Sometimes this hot liquid pours out through cracks in the earth and makes volcanoes. The molten material that comes out from inside the earth is called lava. Volcanoes have destroyed many cities.

In some parts of the world, hot water comes out of the earth as geysers or hot springs.

The energy inside the earth is called geothermal energy. In some places scientists and engineers are trying to draw this heat out by pumping water into deep holes. It is not an easy job and it costs a lot of money."



"It may turn out to be more economical for us in India to use solar energy. The heat from the Sun can be used to heat water in tanks placed on the roof. Sunlight may be converted directly into electricity with the help of what are called photovoltaic cells or solar cells.

Electrical energy cannot be stored except in batteries. Solar energy is produced only when sunlight is present. But we want light when it gets dark. So we have to store solar energy if we want to use it for lighting. It may be used for pumping water. At present solar cells are rather expensive. When solar cells are produced cheaply, these are likely to be used quite extensively."

Forest fire

It was a Sunday morning. Father was reading the newspaper sitting in his easychair on the verandah. Raja was going through the children's section of the Sunday magazine when the news about the terrible forest fire in China caught his eyes.

"Did someone start a fire there?" Raja asked father as he drew his attention to this news.

"Not necessarily, Raja," father said, "a forest fire may start due to various reasons. Sometimes people go to forest for picnic and start a fire which they do not put out when they leave. That can cause a fire. But a forest fire may sometimes start on its own. A tree may catch fire if it is struck by lightning. If two dry trees or branches blown by the wind keep rubbing against each other, a fire may start. A forest fire may cause severe damage."

It takes many years for a forest to grow. It takes only a few days for it to be burnt down.

A forest not only helps clouds to gather and bring rain but also provides a lot of wealth to us. In fact, without forests and trees, a country can turn into a desert.

TASTES A LOT BETTER AFTER IT IS COOKED

"When did man first learn to make fire, father?" Raja asked.

"It is difficult to say, but it must have been over 1,000,000 years ago. Of course, forest fires have been there for a very long time. In fact following forest fires, in which many animals used to be killed, man must have found that roasted meat tasted a lot better than raw meat. That is how man learnt cooking. Man also learnt that by rubbing flint stones together, a fire can be started.

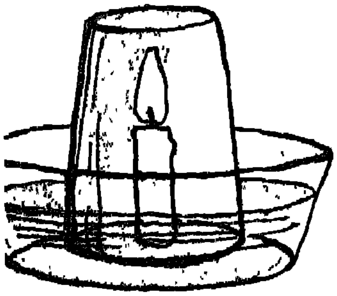
Man used fire not only for cooking but also for keeping wild animals away. Fire was also used to make holes in big tree trunks for making boats. It was nearly 70,000 years ago when man learnt how to use fire for lighting.

The lamps were made of animal fat stored in conch shells with wicks made out of vegetable fibres. Wasn't it a brilliant idea? It is funny to think that, until very recently, man has used similar methods for producing light. Using bees' wax and a wick to make candles, was quite common only a hundred years ago. Thomas Alva Edison used electricity for lighting in 1879. Today we can have light by simply turning on a switch. Unfortunately, in our country, many people still have to use kerosene lamps for lighting their homes."

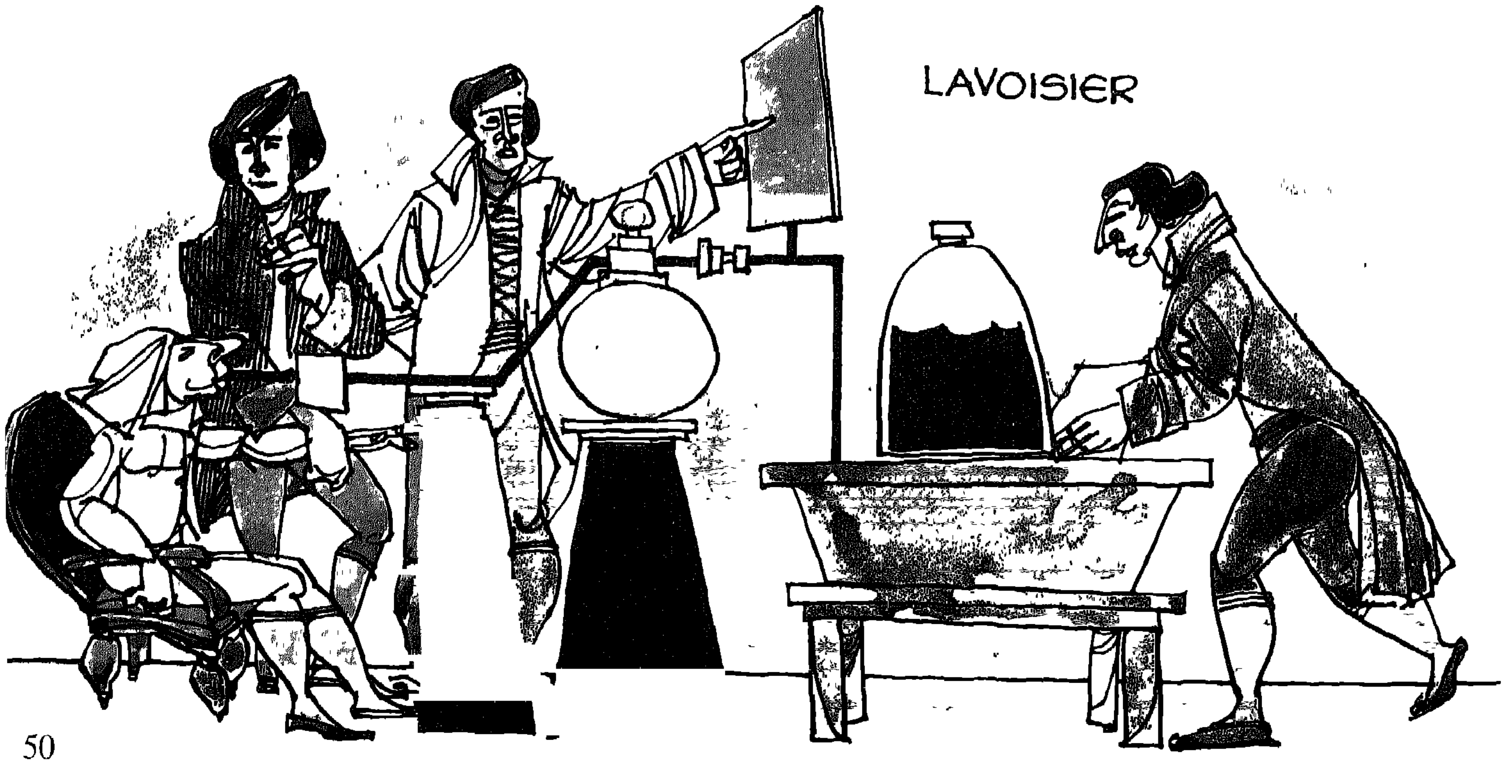
What is burning?

"But father why do wax, oil or kerosene burn?" Raja asked.

"That is a good question, Raja," father said. "In fact we should ask the question, "What is burning?" The answer was not known until only two hundred years back. In early years man feared fire. Man worshipped fire as God. Fire was thought to be a power which could burn and destroy. But scientists were not satisfied with such beliefs.

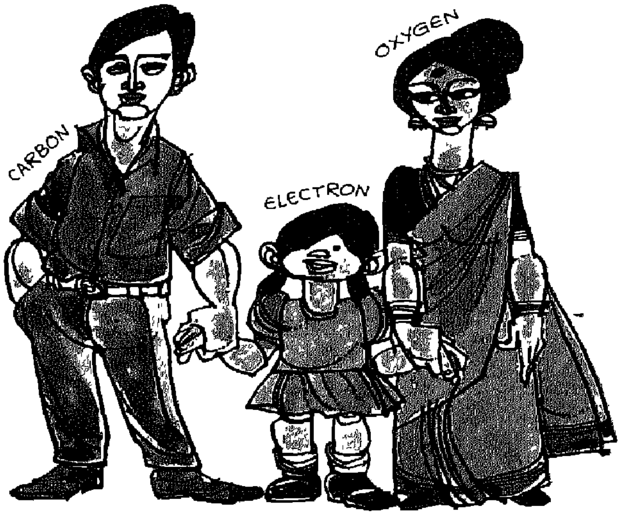


It became clear to scientists in Europe even in the seventeenth century, that a fire can be sustained only in the presence of air. Now you can try a simple experiment yourself. Fix a candle inside a bowl and fill the bowl partly with water. Light the candle and it keeps burning. Take a glass and put it upside down with the candle inside it. The candle burns for some time and then it goes out. You will also see that the water level in the glass rises. What do we learn from this experiment? Firstly that the candle cannot burn in the absence of air. Secondly something inside the glass must have burnt out and water is sucked inside the glass to fill its place. What burns out is Oxygen. You know that air consists mainly of Nitrogen and Oxygen. Out of five parts of air, four parts are Nitrogen and one part is Oxygen . If air consisted only of Oxygen, the candle would have burnt longer and brighter.



All this may seem very simple to us today but scientists did not know anything about Oxygen or Nitrogen. It was in 1774 that an English Clergyman called Joseph Priestley, separated Oxygen, and confirmed that Oxygen is necessary for burning. Priestley could not explain how Oxygen supports burning.

It was Antoine-Laurent Lavoisier (1743-94), a great French Chemist, who suggested that when a substance burns, it combines chemically with Oxygen. The process is called OXIDATION. Burning is nothing but rapid oxidation. Wax, paper, kerosene, are mainly made of Carbon and it is this Carbon that combines with Oxygen and produces oxides of carbon. The details of the process of oxidation were not clear to scientists until recently.



Carbon monoxide

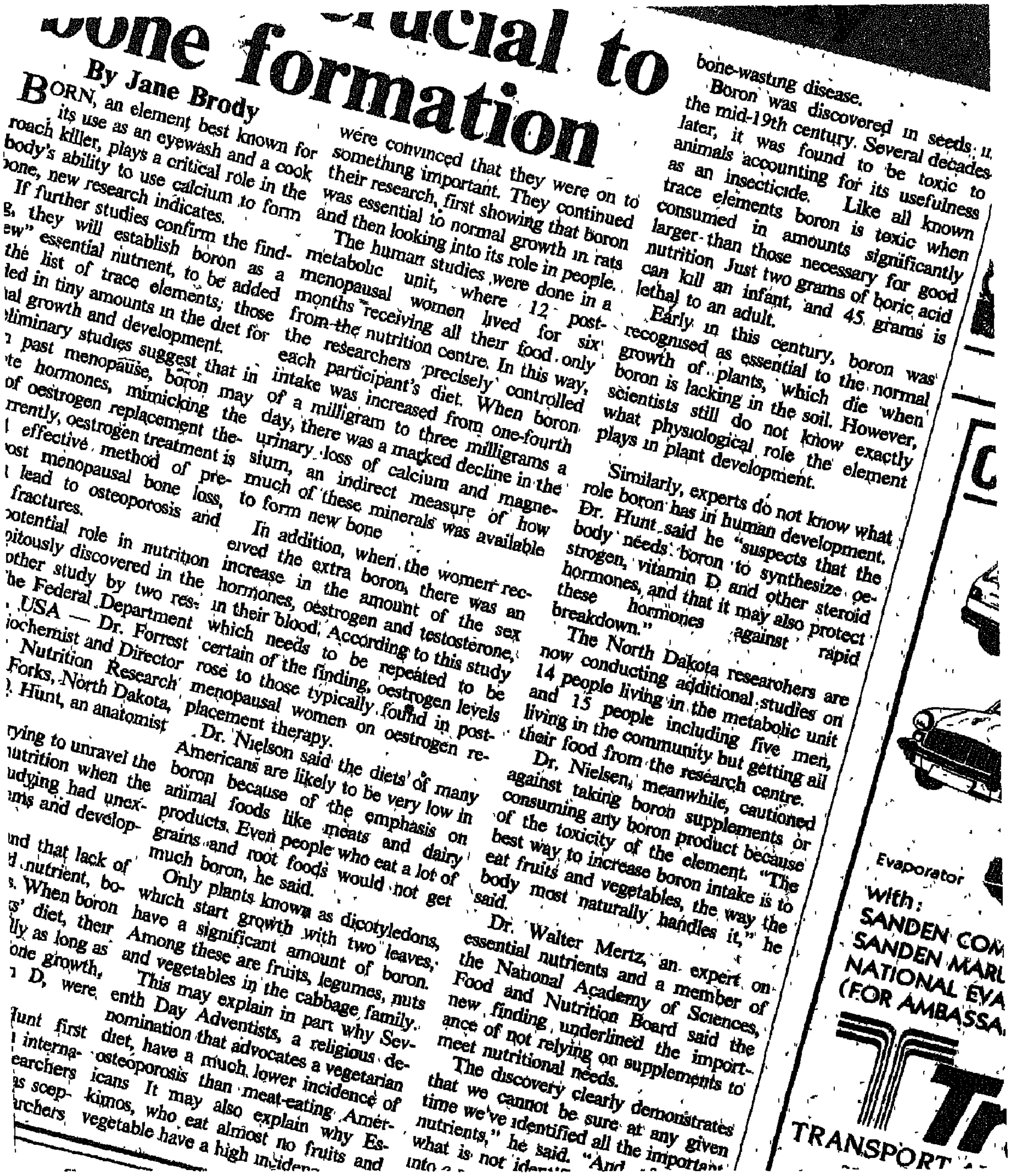
Unstable elements try to combine with other elements and become stable. Oxygen does the same. In the process a lot of heat is given out. A Carbon atom and Oxygen atom share an electron and become carbon monoxide which is a poisonous gas.

If complete oxidation takes place, carbon dioxide is produced."

Antoine-Laurent Lavoisier was a great French chemist. He carried out extensive experiments with utmost accuracy. He was the first person who stated, "Nothing creates itself. In every operation, there is an equal quantity of matter before and after ... there is only exchange or modification." Today this principle is called conservation of matter.

During the French Revolution he was arrested for no fault of his and guillotined. The great mathematician Lagrange said in bitter comment, "It took but a moment to cut off his head. It will take a century to grow another like it."

What turns an old newspaper brown?



ucial to one formation

By Jane Brody

BORN, an element best known for its use as an eyewash and a cook roach killer, plays a critical role in the body's ability to use calcium to form
one, new research indicates.
If further studies confirm the find-
g, they will establish boron as a
ew" essential nutrient, to be added
the list of trace elements, those
led in tiny amounts in the diet for
al growth and development.
liminary studies suggest that in
past menopause, boron may
te hormones, mimicking the
of oestrogen replacement the-
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were convinced that they were on to something important. They continued their research, first showing that boron was essential to normal growth in rats and then looking into its role in people.

The human studies were done in a metabolic unit, where 12 post-menopausal women lived for six months receiving all their food only from the nutrition centre. In this way, the researchers precisely controlled each participant's diet. When boron intake was increased from one-fourth of a milligram to three milligrams a day, there was a marked decline in the urinary loss of calcium and magnesium, an indirect measure of how much of these minerals was available to form new bone

In addition, when the women received the extra boron, there was an increase in the amount of the sex hormones, oestrogen and testosterone, in their blood. According to this study which needs to be repeated to be certain of the finding, oestrogen levels rose to those typically found in post-menopausal women on oestrogen replacement therapy.

Dr. Nielson said the diets of many Americans are likely to be very low in boron because of the emphasis on animal foods like meats and dairy products. Even people who eat a lot of grains and root foods would not get much boron, he said.

Only plants known as dicotyledons, which start growth with two leaves, have a significant amount of boron. Among these are fruits, legumes, nuts and vegetables in the cabbage family.

This may explain in part why Seventh Day Adventists, a religious denomination that advocates a vegetarian diet, have a much lower incidence of osteoporosis than meat-eating Americans It may also explain why Eskimos, who eat almost no fruits and vegetable have a high incide

bone-wasting disease.

Boron was discovered in seeds the mid-19th century. Several decades later, it was found to be toxic to animals accounting for its usefulness as an insecticide. Like all known trace elements boron is toxic when consumed in amounts significantly larger than those necessary for good nutrition Just two grams of boric acid can kill an infant, and 45 grams is lethal to an adult.

Early in this century, boron was recognised as essential to the normal growth of plants, which die when boron is lacking in the soil. However, scientists still do not know exactly what physiological role the element plays in plant development.

Similarly, experts do not know what role boron has in human development. Dr. Hunt said he "suspects that the body needs boron to synthesize oestrogen, vitamin D and other steroid hormones, and that it may also protect these hormones against rapid breakdown."

The North Dakota researchers are now conducting additional studies on 14 people living in the metabolic unit and 15 people including five men, living in the community but getting all their food from the research centre.

Dr. Nielsen, meanwhile, cautioned against taking boron supplements or consuming any boron product because of the toxicity of the element. "The best way to increase boron intake is to eat fruits and vegetables, the way the body most naturally handles it," he said.

Dr. Walter Mertz, an expert on essential nutrients and a member of the National Academy of Sciences, Food and Nutrition Board said the new finding underlined the importance of not relying on supplements to meet nutritional needs.

The discovery clearly demonstrates that we cannot be sure at any given time we've identified all the importan
nutrients," he said. "And
what is not ide
into a

Evaporator
With:
SANDEN COM
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TRANSPORT

Oxidation that occurs naturally is very slow. When a newspaper left for many months becomes brown, it means slow oxidation has taken place. If we light a paper with a matchstick we help a number of molecules of Carbon to break into atoms which combine with Oxygen. As a result heat is produced, more molecules break down and a chain reaction follows and a FIRE IS CAUSED.

Raja's mother always cooked something special for Sunday lunch. She had just served lunch when father told her somewhat casually, "A man will come tomorrow with a gas cooker and a cylinder. Show him where you want to place them."

Mother was surprised, "A gas cooker! You never told me you were going to buy one! I can't believe it."

"I meant it to be a pleasant surprise for you," father said smilingly.

Mother looked very pleased. Prabha and Raja were also very pleased.

"Ma, do you remember how the walls of our kitchen were always black when you had that *chulha*?" Prabha asked.

"Don't I remember. Raja and you used to suffer from cough and cold because of the smoke. We changed over to the kerosene stove but it is slow and we don't have a regular supply of kerosene. Cooking with gas is going to be wonderful," mother said.

"How much gas would a small cylinder hold?" Raja asked.

"A gas cylinder is filled with a liquid called Liquefied Petroleum Gas or LPG. This liquid turns into gas as soon as it is released through a narrow passage called the nozzle. This gas is a hydrocarbon which means that it is a compound of hydrogen and carbon. When it burns in the presence of oxygen, it produces a lot of heat," father said.

"Is this gas dangerous?" mother asked apprehensively.

"Not if we are careful," father said. "This gas can kill if we inhale it for a long time. It is also very explosive. But LPG has a very strong smelling substance mixed with it and you can detect even the slightest leak. As soon as you smell gas, you must shut off the cylinder and make sure that you do not light a match stick near the cylinder."

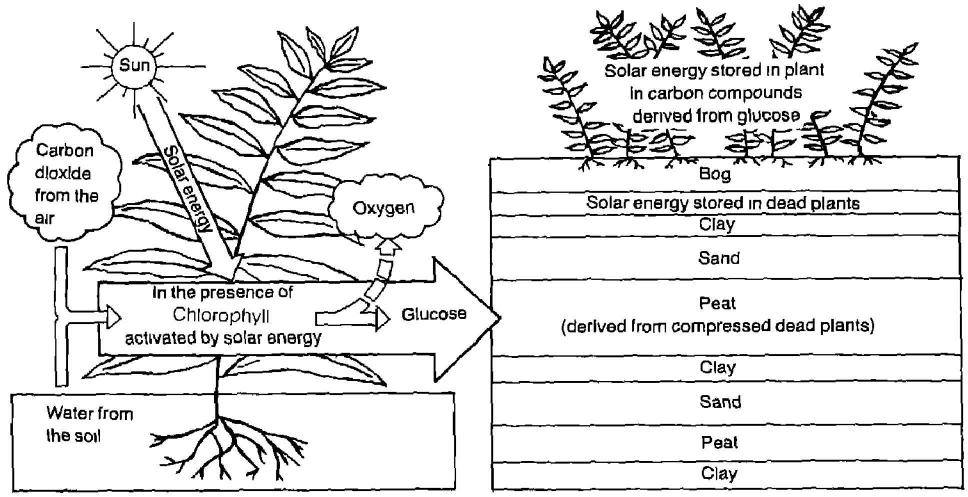
"Where do we get LPG from, father?" Raja asked.

"Let your father have his food please, Raja" mother intervened. "He will tell you all about it later."

What is black diamond?

After lunch, father took out a copy of Popular Science from the shelf and called Raja. Mother and Prabha also joined them. "Let us see how coal and oil are produced," father said. "Believe it or not Raja, the energy of coal and oil are also derived from the Sun.

Let us first look at this picture on coal formation.

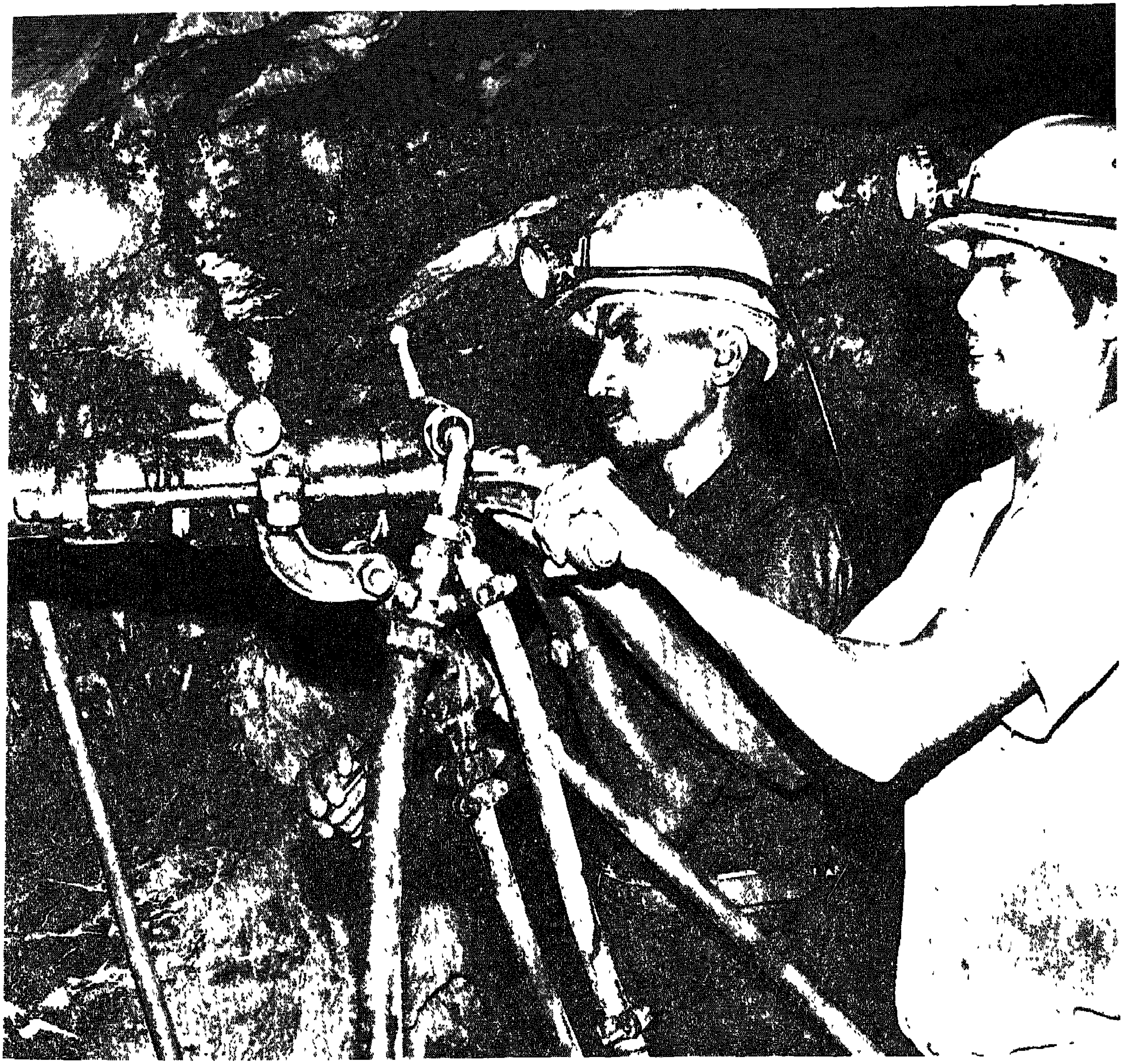

Sun
Solar energy
Carbon dioxide from the air
Oxygen
In the presence of Chlorophyll activated by solar energy
Glucose
Water from the soil
Solar energy stored in plant in carbon compounds derived from glucose
Bog
Solar energy stored in dead plants
Clay
Sand
Peat (derived from compressed dead plants)
Clay
Sand
Peat
Clay

You know how trees derive energy from the Sun through photosynthesis. Although we would have to spend a lot of heat energy to break water molecules into hydrogen and oxygen, chlorophyll present in leaves can do so very easily with the help of sunlight. Carbon dioxide breathed in through stomata or pores in the leaves combines with water to give glucose. Oxygen is breathed out by the plants. Complex compounds of carbon are produced and stored in the trunks and the branches of the trees. When the trees die they fall down. More trees fall and these trees keep sinking into the earth, and are compressed. They turn into what is called peat. Heat and pressure inside the earth turns peat into coal. The process of course takes millions of years. Men have been using coal for thousands of years. Coal not only produces 'heat' but it provides steam power, electricity and chemicals like Tar, Benzene, Naphthalene, etc. That is why coal used to be called Black Diamond."

"Do we have a lot of coal in our country, father?" Prabha asked.

"Yes, we have enough to last about 100 years. Coal in India is found mainly in West Bengal, Bihar and Madhya Pradesh Mining of coal is not an easy job and it involves a lot of risk. Miners go down inside mines and dig. Sometimes accidents take place and miners may be killed. Although accidents are fewer these days, coal mining is still difficult and dangerous.

In India coal is used mainly for producing electricity and running steam engines. It is also widely used for cooking and as your mother told you the smoke from *chulha* is bad for health."

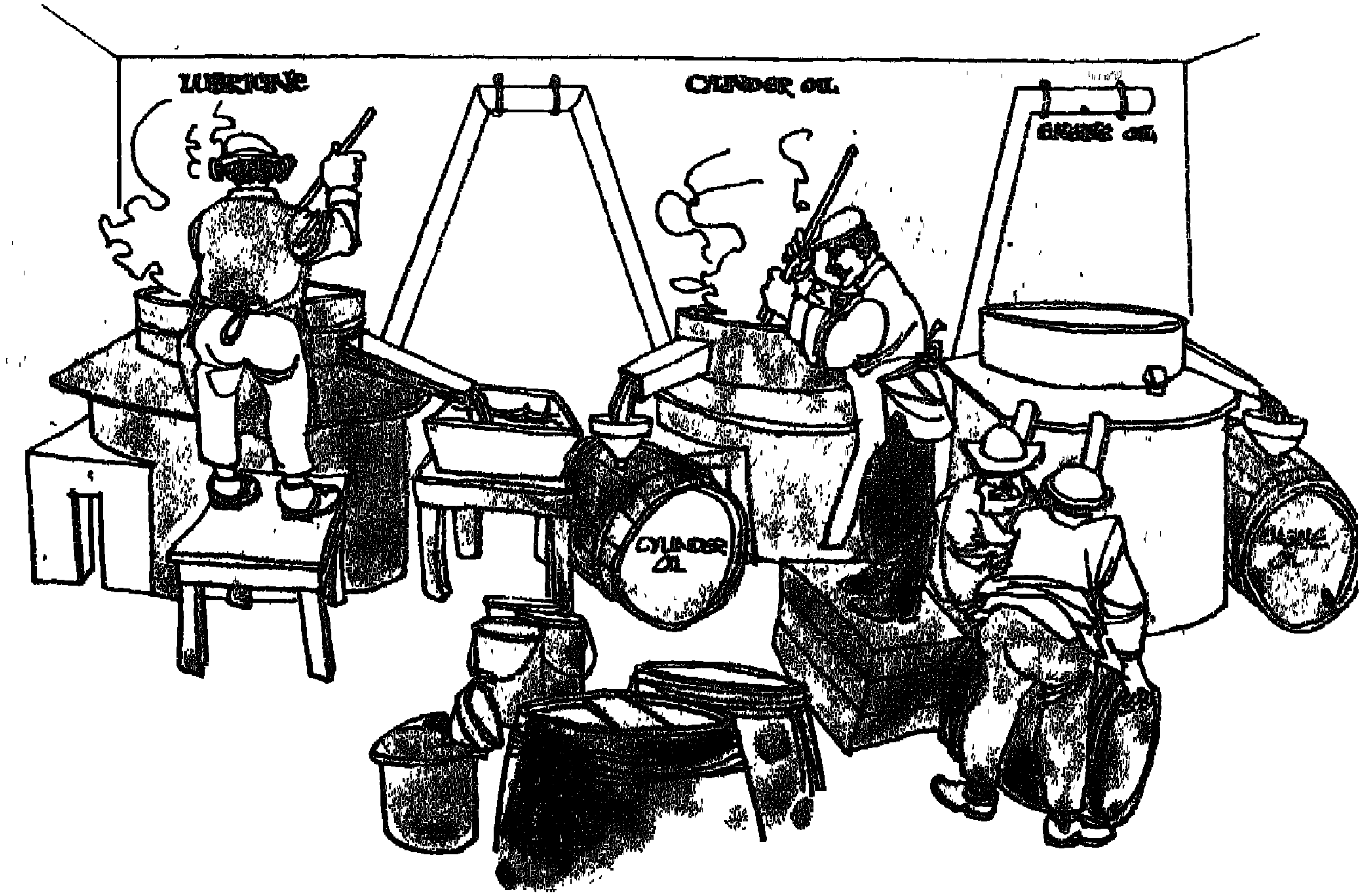


What is liquid gold?

"Can you guess what is called 'Liquid gold'?" father asked.

"Is it petrol, father?" Prabha asked.

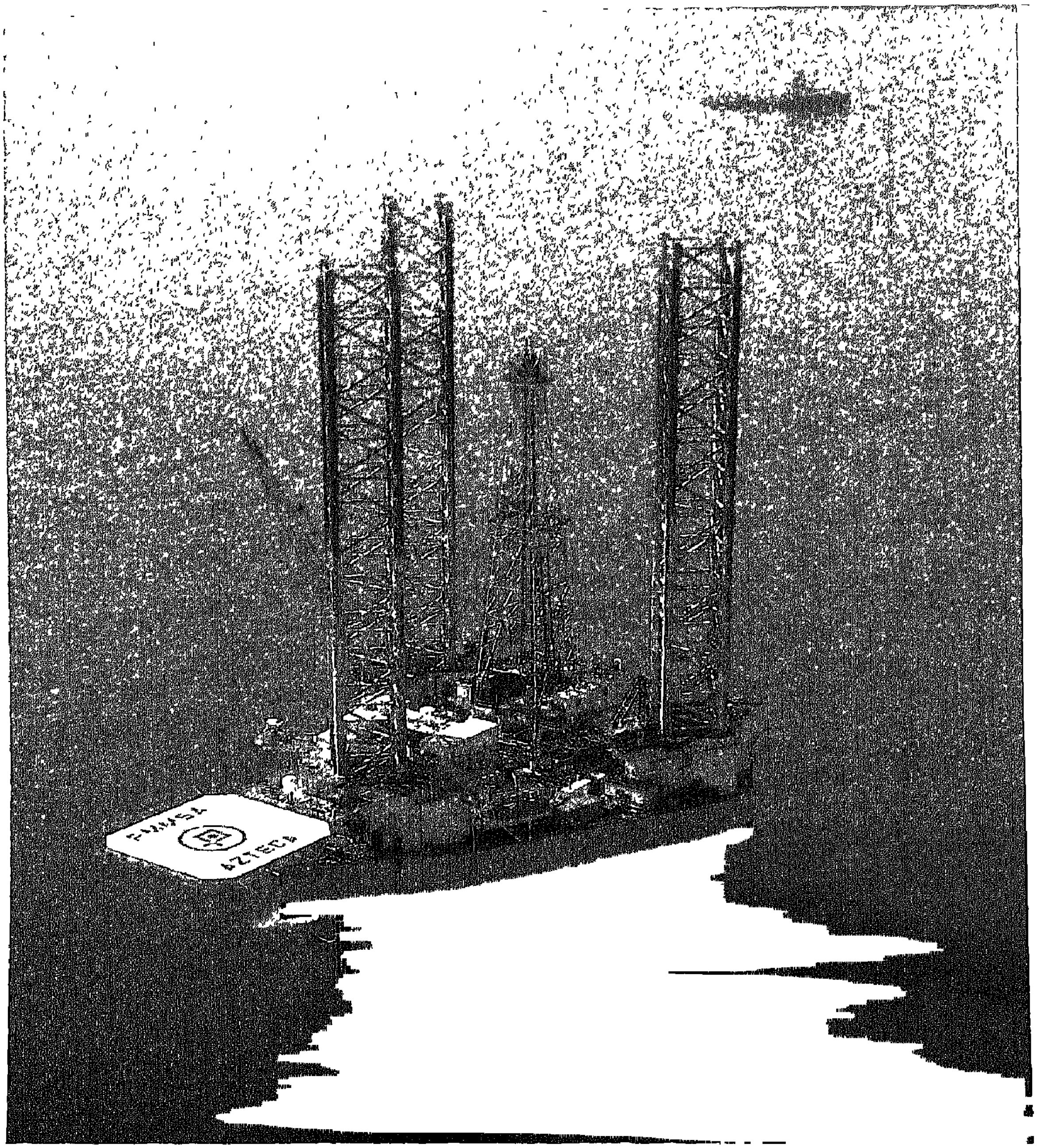
"Petroleum to be precise," father said. "Petrol is just one of the many by-products of petroleum. As trees buried under the earth turn into coal, animals which died and were covered under seabeds become subjected to heat and pressures. In millions of years they turn into oily masses which give petroleum. That way the energy of petroleum also came from the Sun," father said. The first oil well was sunk in 1859 in Pennsylvania in the United States although man knew about the dark, sticky crude oil which oozed from cracks in the earth. This sticky substance was used by Persians as a glue for constructing buildings over 6000 years back. We know today that there is plenty of oil in countries like Saudi Arabia, Kuwait, Iran, Iraq or what we call the Middle East countries. Hundreds of years ago when this oil was not drilled, it used to seep out through cracks in the earth. These seepages were sometimes ignited by chance and became the "eternal fires" which the Persians worshipped.



In 1806 in West Virginia in the United States, some engineers began to drill wells to get brine or salt water. They were very annoyed when some black oily substance was mixed with the brine. Some of them even abandoned the wells. They did not realize that this oily mass would one day turn out to be so valuable that people would call it liquid gold.

In India, oil was first produced in Digboi in Assam. The quantity is not large and does not meet all our needs. We also get oil from the Arabian Sea from a well called the Bombay High. We still have to buy oil from outside in order to meet our requirements.

"How does one drill a well under the sea, father?" Raja interrupted.

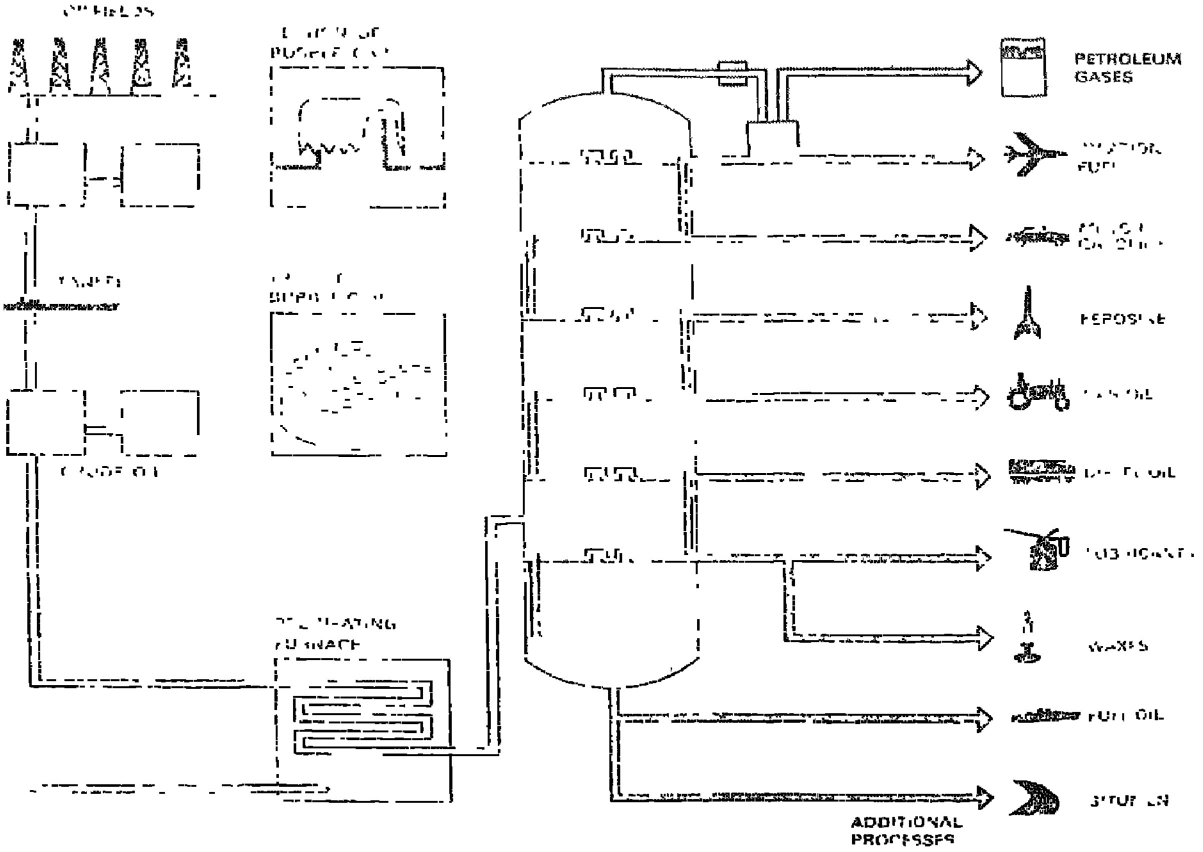


"Look at this picture. A platform with three or four legs is placed where drilling is to be carried out. The legs are lowered if the sea bed is not too deep. A drill digs a hole and steel tubes are fitted into the hole that is dug. Sometimes engineers dig as deep as 5 km into the earth and still do not find anything. They abandon the well and start somewhere else," father said.

"Do they go on drilling wells at random, father?" Prabha asked.

"Not entirely. Scientists carry out surveys, and try to determine the structure of the earth below the surface. The structure indicates whether oil may be available or not," father said. "Look at this picture and see how many chemicals are obtained from crude oil. Almost every drop of petroleum is useful to us. Aeroplanes, diesel engines, motor cars, mopeds use kerosene, diesel or petrol."

All that we get from oil



"Father, what will happen when all the petroleum runs out?" Prabha asked.

She was always worried about things running out.

"That is a good question. Petroleum and coal will run out one of these days. We shall probably find other sources of energy. But you are right. We have to be careful and use energy so as not to waste it. When one person travels in a car, he is wasting petrol. That's why we should travel by buses and vans and use bicycles whenever we can," father said.

"We do not waste petrol. We do not have a car or a moped," Raja said.

"That's right," father said, "we cannot afford a car either."

"We are happy with our bicycles, aren't we, father? "Prabha said.

"But, I haven't got a bicycle,"Raja said.

"All right, I shall buy one for your next birthday,"father said.

Raja could not believe his ears. He ran to mother to give her the good news.

"Wish all mothers had gas cookers"— Owl

It was a Tuesday and Raja went out as usual to meet Owl. As soon as he saw Owl, Raja said excitedly, "You know Owl, father has bought a gas cooker for mother. It is so nice and clean and cooks so fast! Mother is very happy."

"I am so glad Raja. I wish all mothers had gas cookers," Owl said.

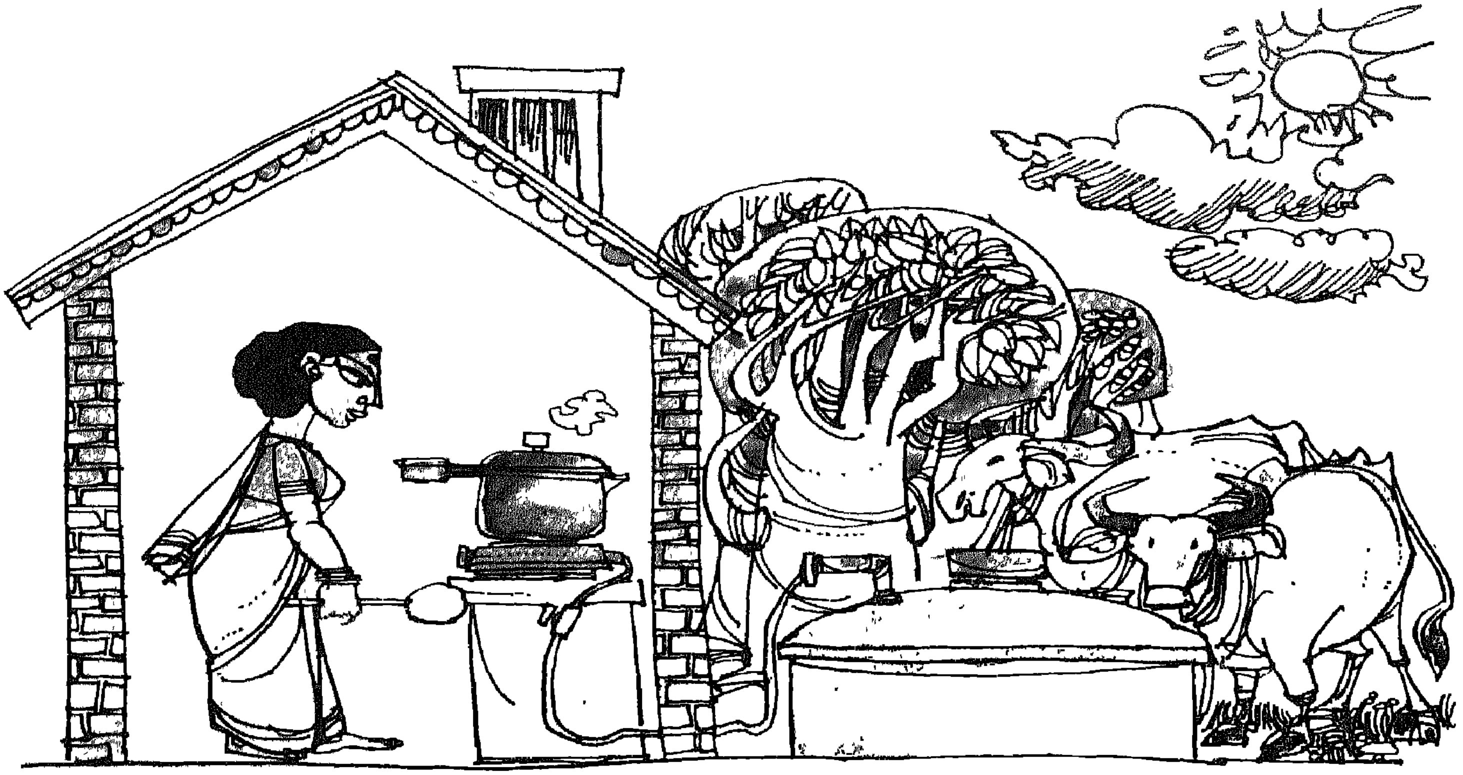
"Do most of them use coal like my mother used to?" Raja asked.

"You see Raja, I keep flying all over the place and I see how our women struggle to make a fire for cooking. Some use coal. Smoke fills their rooms and kitchens and smoke is bad for health. Some cannot even afford to buy coal. They use cow dung cakes and firewood. Sometimes women and even small children like you walk miles to collect twigs and branches. In villages whatever energy people use, is mostly for cooking purposes. They use animal energy for farming and of course they use their own energy. They work very very hard," Owl said.

"How do they light their homes at night?" Raja asked.

"Well, many villages have electricity now. But most poor people cannot afford electric power. They use kerosene lamps for lighting. Sometimes they do not even have kerosene and spend their nights in darkness. It upsets me when I see their sufferings," Owl said.

Raja also felt sad. He hadn't realized that so many people in our country suffer because they cannot buy energy.



Will – O' – the – Wisp

Owl felt sorry that he had upset Raja. He said, "Things are improving now, Raja. Today most villages in our country have electricity and it is used for pumping water for irrigation."

"What is irrigation, Owl?" Raja asked.

"Irrigation means providing water for the soil for growing food. Earlier we used to depend only on the rains. People starved and died if rains failed. Cooking and lighting are still major problems for a large number of people in our country," Owl said. "It is necessary to improve the chulahs. We should have bio-gas plants for cooking and lighting."

"What are bio-gas plants?" Raja asked. Owl knew that Raja would ask this question.

"If you put cow dung and water in a pit, and seal off the mixture from air, a gas called methane is produced. Methane burns very well and produces heat and light. Have you ever seen 'Will O the Wisp,' Raja? I see plenty of it when I fly over marshy lands at night," Owl said.

"What is that?" Raja said. "I have never heard of it."

"Well it is a kind of light which suddenly flashes on marshy areas and then disappears. People thought it was a ghost. It is nothing but methane gas which is produced on marshy land. This gas can flare up all of a sudden." Owl said. Then he took leave of Raja promising to return the following week.

Kite flying that could have been fatal

Raja was on his way home from school. The sky was overcast with black clouds. It was going to rain. Raja looked at the sky. Lightning flashed followed by rumblings of the clouds. Raja entered the forest to take a short cut, although he had heard that it was not safe to stand or pass under trees on a stormy day. Trees may be struck by lightning which could kill anyone standing underneath. Raja had begun to run when he saw Sthula coming towards him. Raja climbed on Sthula's back and felt greatly comforted.

"What is lightning, Raja do you know?" Sthula asked.

Raja had heard from his father that lightning is nothing but electrical discharge.

He wasn't quite sure how it was formed.

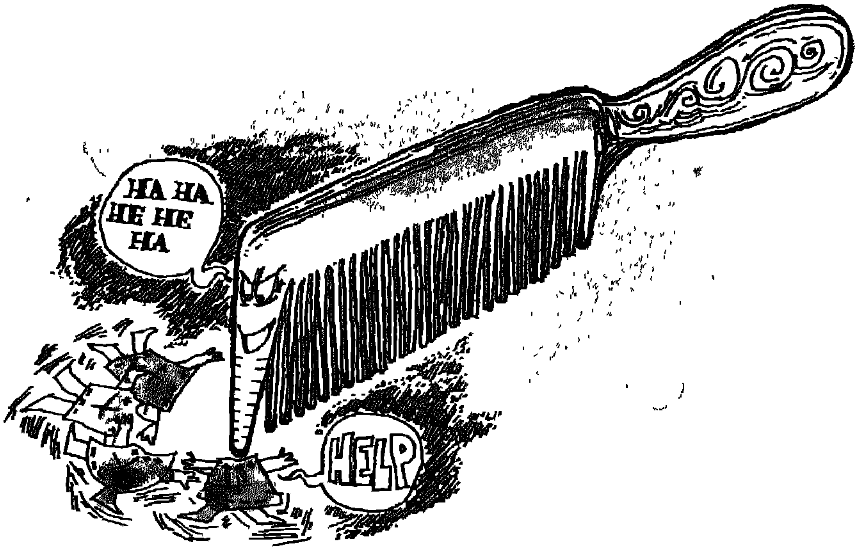
"It is electricity, Sthula," Raja said, "you know what we have at home, lighting up the bulbs and running the fans. But lightning is much stronger. Of course, nobody knew that until Benjamin Franklin found it out.

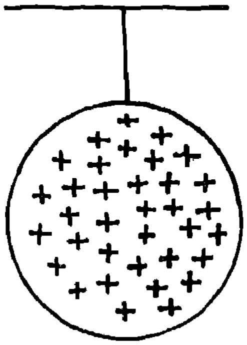
"On a cloudy day like this he flew a kite into the clouds. He used linen thread to fly the kite and he tied a key to the thread. He tied a silk ribbon to the key and held the ribbon in his hand. It began to rain and Franklin brought his knuckle near the key. A spark flew."

Sthula started moving fast. He did not want Raja to get wet. Sthula dropped Raja at the edge of the forest and Raja ran as fast as he could. As soon as he reached home, the rain came pouring down.

The charge in the cloud and in the comb is the same

If an atom loses its electrons, it becomes positively charged. Positive and negative charges attract each other. Like charges repel. Positive charges on the sphere pull electrons in the girl's hair towards the sphere. Her hair stands up and the strands also push each other away because they have similar charge.


HA HA HE HE HA
HELP



Father was sitting inside with a cup of tea and was relieved to see that Raja was not caught in the rain. After Raja had his food, he sat with his father. "You know father, you had told me the story of Benjamin Franklin but you did not tell me how electricity is formed in the clouds," Raja said.

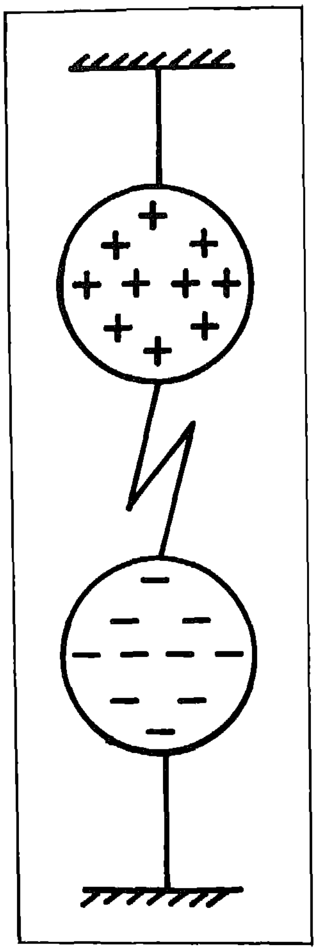
"All right," father said, "bring a comb and something woollen. I will show you how electricity is formed." Raja ran inside and brought mother's comb and his own woollen vest.

Father tore a piece of paper into small bits. He rubbed one end of the comb with the wool and held it close to the pieces of paper.

The pieces of paper stuck to the comb as if it was a magnet. Raja had seen Bipin doing this once but did not understand what it had to do with lightning.

"When you rub the comb with wool, some electrons from the wool flow to the comb. The comb becomes negatively charged with an excess of electrons. As soon as you bring the comb near the pieces of paper, electrons in the paper near the comb are pushed away leaving excess positive charges there. Then the negative charges of the comb pull the positive charges.

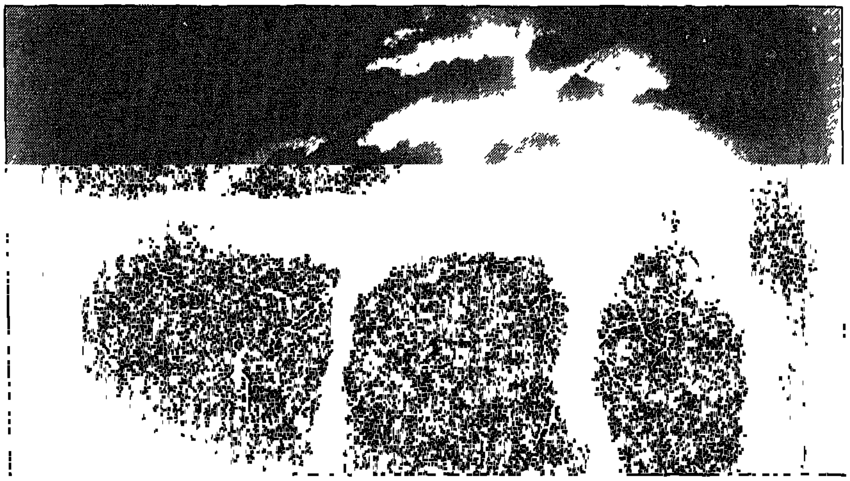
The pieces of paper being light are also pulled towards the comb."



If two big spheres, are charged, one positively and the other negatively, they cannot move towards each other.

Electrons from the negatively charged sphere, stretch out towards the positive charges of the other.

As the electrons flow through air, air becomes so hot that it glows. We see sparks.



How do the clouds become charged?

Clouds, as you know, are made of water vapour. Since it gets cooler and cooler as we go further up in the sky, the vapour condenses into water droplets. These droplets turn into pieces of ice and start falling as they become heavy. Billions of such particles rub billions of water molecules millions of times.Slowly the whole cloud becomes charged.

Sparks fly from cloud to cloud, and between the clouds and the earth. Since the air becomes hot, it produces a huge crackling sound which we call thunder.

Suddenly there was a flash of light in the clouds and seconds later there was a series of rumbling sound.

How far is the thunder cloud?

If you want to measure how far the thunder clouds are you can do it the following way. The moment you see the flash, start counting one hundred and fiftyone, one hundred and fiftytwo and so on until you hear the first rumbling noise. It takes about a second to say 'One hundred and fiftyone'. If you have counted up to one hundred and fiftysix, it means 6 seconds have passed in between. Now light travels at 300,000 kms/sec and sound travels at about 330 metres/sec or one kilometre in 3 seconds. As soon as lightning occurs, light reaches you almost immediately. Sound takes longer If you have counted six seconds, divide 6 by 3 and the thunder cloud is 2 kilometres away.

"Can you find a lemon, Keshav?" Raja asked.

"We have plenty of them in the back garden. What do you want a lemon for?" asked Keshav.

"I will show you in a minute. Let's get one," Raja said. Raja and Keshav took a large lemon. Raja had a strip of Copper and a strip of Zinc which he had collected from an old torch cell. He cut two slits in the lemon and pushed the Zinc and Copper strips inside the lemon. He touched the other ends of the strips with the tip of his tongue and felt a tingle.

"Like to try it Keshav?" He gave the lemon to Keshav. Keshav hesitated and then he also touched the ends of the metal with his tongue and felt a tingle. "That's electricity, Keshav, current electricity. Father told me last night," Raja said. "Alessandro Volta discovered it. People had discovered static electricity by rubbing glass or something called Amber with silk or wool."

"I know about static electricity," Keshav said, "I have a nylon vest. When I take it off it makes crackling sound. Mother said, it is due to static electricity."

Why did the frog's legs twitch?

"That's right," Raja said, "Have you heard of Galvani, Keshav?"

"No", Keshav admitted.

"I hadn't heard of Galvani or Volta either," Raja said, "Father told me about them last night. They were two well known professors in Italy. One day Galvani noticed that a frog's leg hanging from brass hooks twitched as soon as it came in contact with some other metal. He called it animal electricity. He was wrong, father said. Professor Alessandro Volta showed by experiments that electricity is produced when two different metals separated by a chemical are connected by something that allows current to flow. The frog's leg twitched because electricity passed through it. Just like we felt when we touched these metals with our tongue. Father said that electric batteries are made the same way. Have you got a compass, Keshav?"

"Yes, I have one in my instrument box," Keshav said.

"Not a draftman's compass. I want one which has a magnet inside," Raja said.

"Abdul has one. Let's go to his house," Keshav said and off they went.

Electric current deflects a magnet

Luckily Abdul was at home. He had quite a collection of things. A small compass, a magnet, two cells of a torch, a bulb and some wire of different lengths. He also showed pictures, from a book from which he often tried to do experiments.

Magnets always fascinated Raja. He picked up the magnet and held it near the compass. The compass needle which had been pointing North moved away.

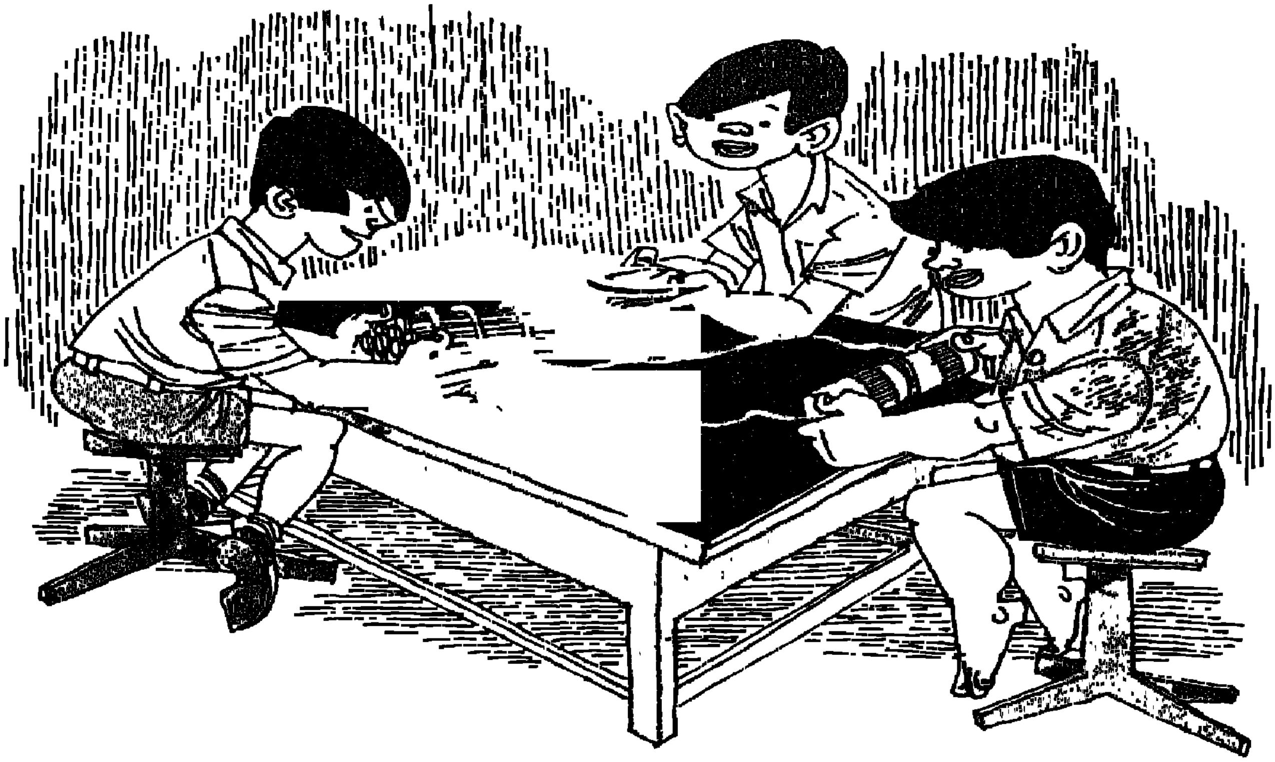
"Do you know what makes the earth a magnet, Abdul?" Raja asked.

"I was told that the inside of the earth is filled with hot liquid metal which keeps churning. That makes the earth into a magnet," Abdul said.

"Why should churning metal produce a magnet?" Keshav asked.

I am not very sure but I know there is a relationship between electricity and magnetism. It is described in this book. I shall show you in a minute," Abdul said.

"Oersted was a Danish professor who accidentally saw one day, when he was teaching in a class, that a compass needle deflects when electric current flows through a wire held nearby. Want to see?"



Abdul took a long thin wire which he said was insulated and wound it several turns around a bunch of long thick iron nails. He placed the compass near one end of the nails and touched the two ends of the wire to the two ends of the cell. The magnet of the compass was immediately deflected. The needle came back to its North-South position as soon as Abdul disconnected one of the ends of the wire from the battery.

"When current flows through the wire, nails become magnets. Even if you remove the nails, the coil behaves like a very weak magnet," Abdul said. He removed the nails and again connected the two ends of the wire to the cell and the compass needle was slightly deflected.

"It was Michael Faraday," Abdul said, "who showed that if we rotate a magnet or an electromagnet inside a coil, we can produce electricity."

"What is an electromagnet?" Raja asked. "This coil and the nails make an electromagnet. The bunch of nails becomes a magnet when electric current flows through the coil. Wait! I will show you," said Abdul, turning the pages of his book. There they read a short biography of a young bookbinder whose name was Michael Faraday.

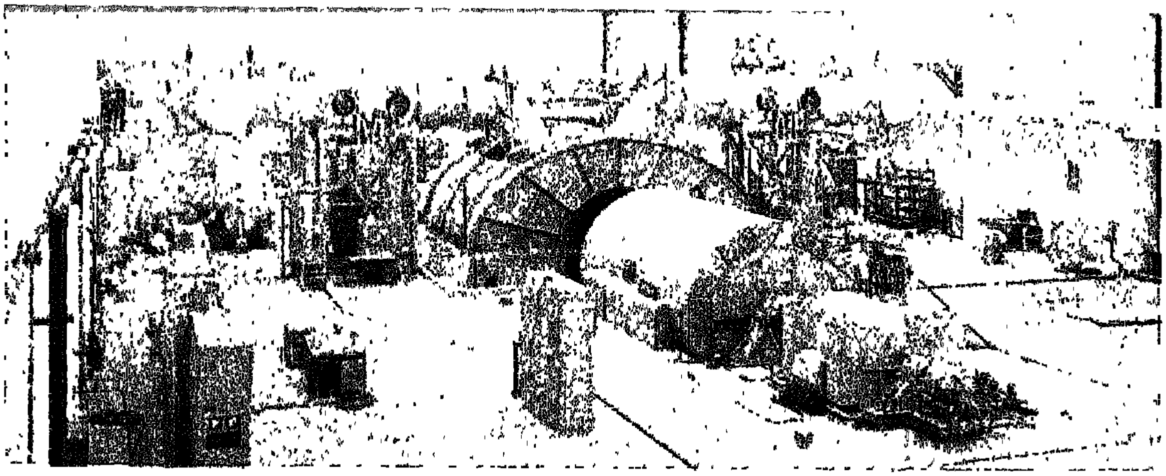
Michael Faraday

Michael Faraday was born in Surrey in England in 1791. His family was poor. Michael never went beyond elementary grades in school and at the age of thirteen he became an apprentice to a bookbinder. He loved reading the books that came for binding, especially, the books on science. Once he received a free ticket to attend the lectures of Sir Humphry Davy who was a great scientist. Michael took careful notes of the lectures and sent the notes to Davy "as proof of my earnestness" as he said. A few days later a coach drew up near Faraday's humble home and a footman delivered a letter from Sir Humphry Davy inviting Michael to call at the Royal Institution in London.

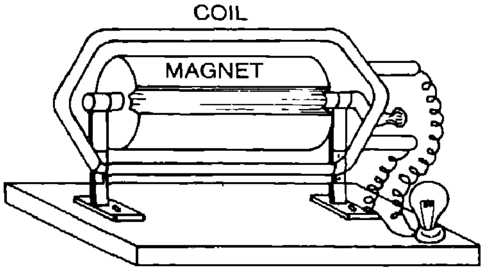
Michael was appointed Davy's assistant at 25 shillings (about 25 rupees) a week. Michael could not ask for anything better. Davy soon recognized Faraday's genius. Faraday made many discoveries in chemistry, electrochemistry and electromagnetism.

Electric generators that give us electrical energy and electric motors which run fans, cranes and rail engines, resulted from the discoveries of Michael Faraday and, a lesser known genius called Joseph Henry.

Michael Faraday is often described as the greatest experimental physicist that ever lived. When Sir Humphry Davy was asked to name his greatest discovery, he promptly replied, "My greatest discovery was Michael Faraday."



Generators and motors



Rotate a magnet (or an electromagnet) inside a coil. Electricity is produced. We have a *Generator*

Place a magnet (or an electromagnet) inside a coil and pass electric current through the coil. The magnet rotates. We have a *Motor*.

The generators and motors made a hundred years ago were small.

Today 500 megawatt generators are common. How much is 500 megawatt? Well, 'mega' is a million. Just one 500 megawatt generator can light up 5 million 100 watt lamps.

How are large generators rotated?

They are rotated by turbines. Turbines are rotated by steam or water at very high pressure. Electricity is often produced at 11,000 volts. The voltage is increased by a transformer and sent through transmission lines.

But what is voltage?

Voltage is a pressure of electric power and is named after Alessandro Volta. Current is the flow of electric charges and is called Ampere after Andre Ampere. Power is flow times pressure or current times voltage. It is called Watt after James Watt.

A 100 watt bulb glows brighter than a 60 watt bulb. But a 60 watt bulb burning for 5 hours consumes more energy than a 100 watt bulb burning 2 hours.

ENERGY IS POWER
MULTIPLIED BY HOUR

Raja was startled. He remembered the song the Owl had taught them. He could not figure out how the author of Abdul's book came to know about it. Anyway, it was getting dark. Raja and Keshav thanked Abdul and left for home.

What has sound got to do with energy?

It was nice to meet everyone in the forest after a long time.

"Where is Pashuraj?" Raja asked.

"Right here," Pashuraj roared and jumped in.

Everyone except Sthula was startled.

"What a roar," Goat said.

"Waste of energy if you ask me," Markata said.

"Mind your own business. Besides what has sound got to do with energy? " Pashuraj asked Markata.

"Sound is also a form of energy," Owl said.

"Is that so?" Raja asked.

"Yes indeed. If you clap your hands, mechanical energy changes to sound energy. If you sing, chemical energy stored in your body makes your vocal chords vibrate and sound is produced," Owl said.

"Isn't he learned?" Goat whispered to Sthula.

"He says difficult things," Sthula said.

"Anyway, the energy contained in sound is not very much," Owl continued. "You see, Raja, if you and I keep talking for one whole year the energy of the sound, if turned into heat, will not be enough to boil even a cup of water."

"I think that is rubbish," Pashuraj said.

"Even if you keep roaring, Pashuraj, it will not make much difference,"Owl said.

"What if I trumpet?" Sthula asked and trumpeted as loud as he could.

"There they go again," Markata said, as he covered his ears.

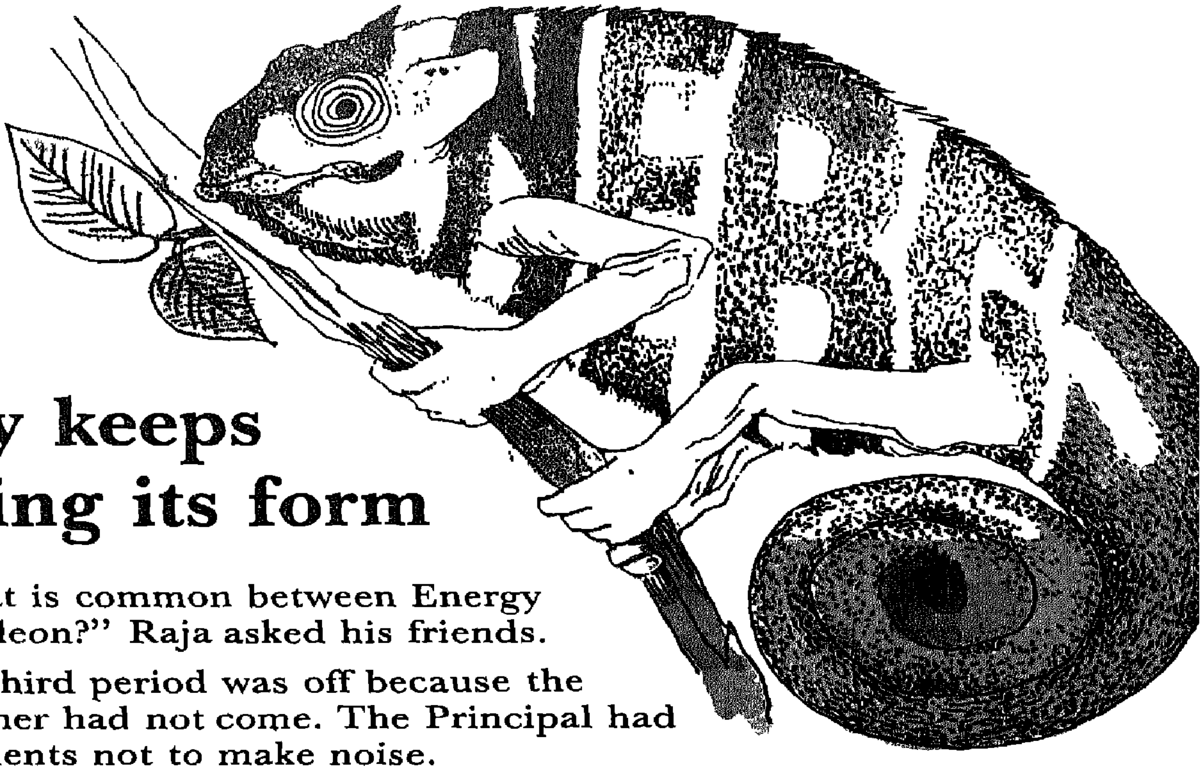
"Well, I must confess that it is very loud," Owl said, "but it does not contain much energy either. What I mean is that the capacity of sound for doing any useful work is very limited."

"Except of course bursting our eardrums," Markata added.

"And mind you, sound travels very slowly compared to heat, light and radio waves which travel very fast."

Raja knew it. He had learnt from father that light travels 300,000 kilometres per second while sound travels only at about 1/3 kilometre per second.

BOOOM
GRRR



Energy keeps changing its form

"What is common between Energy and a chameleon?" Raja asked his friends.

The third period was off because the English teacher had not come. The Principal had told the students not to make noise.

"What is a chameleon?" Keshav asked.

"It is like a lizard. It changes colour. You must have seen one, Keshav."

No one could answer.

"I will tell you," Raja said. "Energy changes its form like a chameleon changes its colour."

"What do you mean by energy changes its form?" Sudha asked.

"Well, light from the Sun becomes chemical energy and is stored in food, coal and petroleum. Chemical energy turns into heat. Heat turns into mechanical energy. Mechanical energy produces electricity. Electricity gives heat and light. So you see how Energy changes its form?" Raja did not tell his friends that Owl had told him all this the previous night.

"All right," Bipin said. "Can you explain this riddle?"

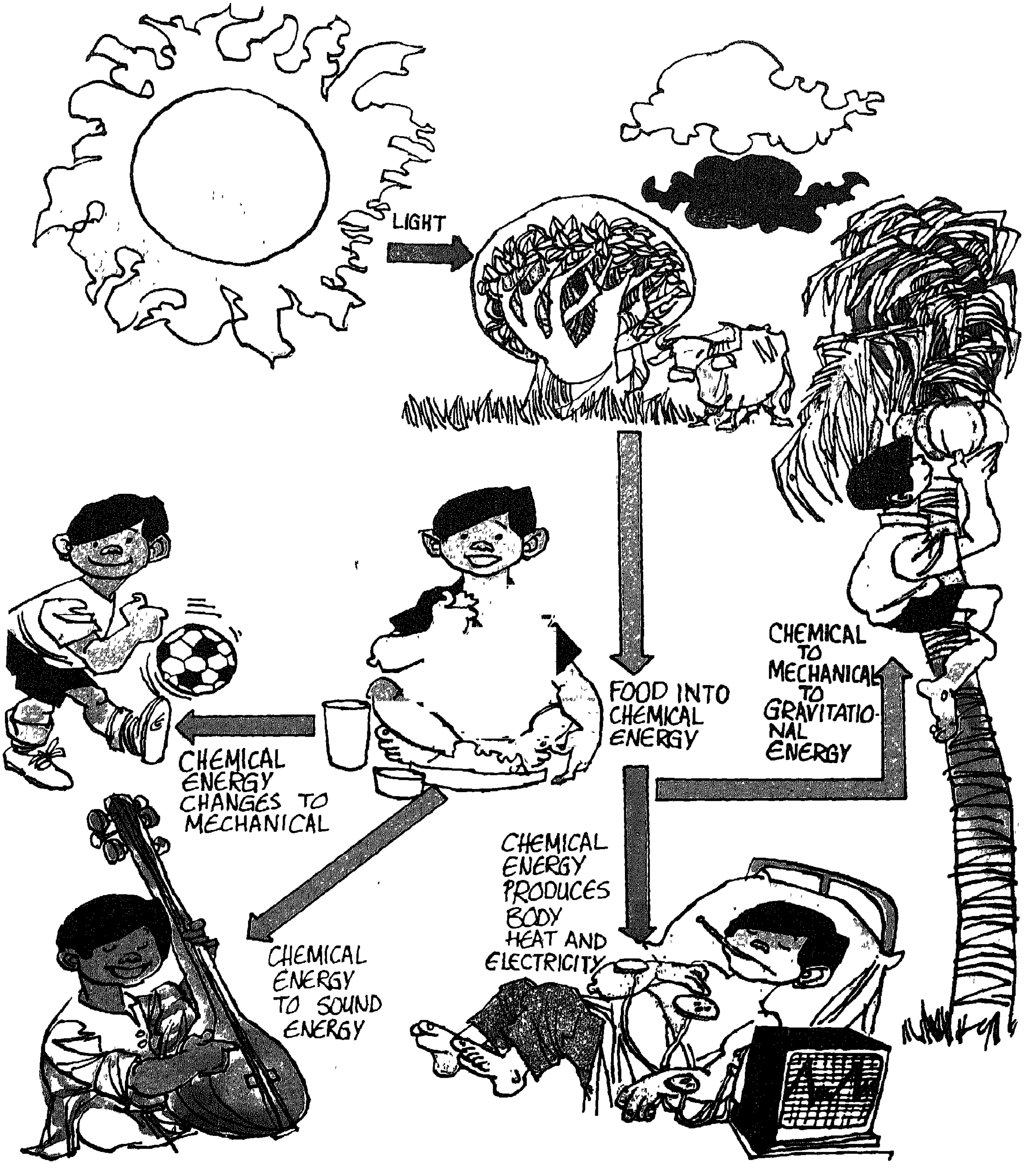
"Mag Mo El
And El Mag Mo
Go round and round
Yo Ho Ho Ho."

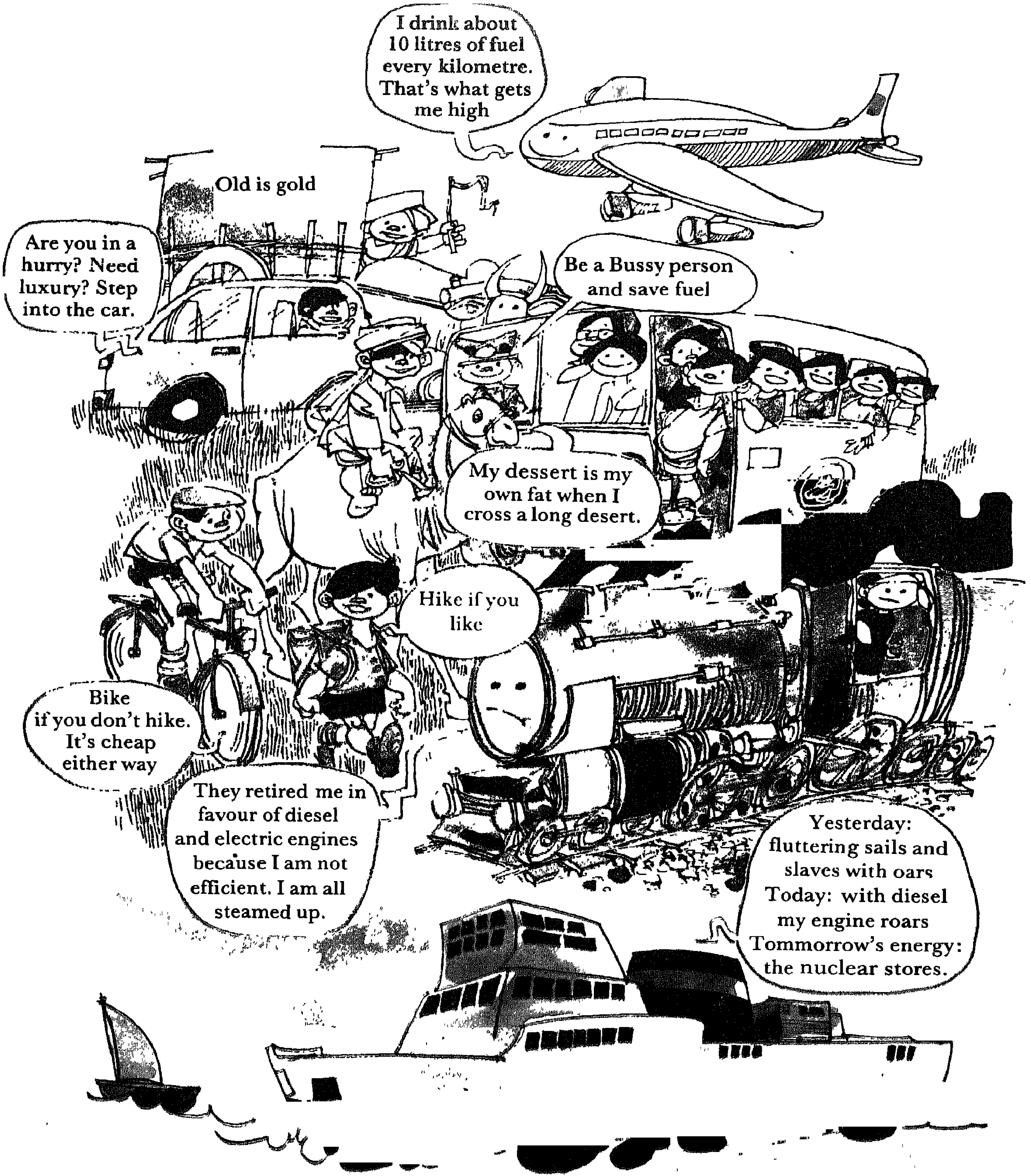
Everyone looked puzzled. Bipin proudly recited:

"A **Mag**net in **Mo**tion produces **El**ectricity, that is a generator.

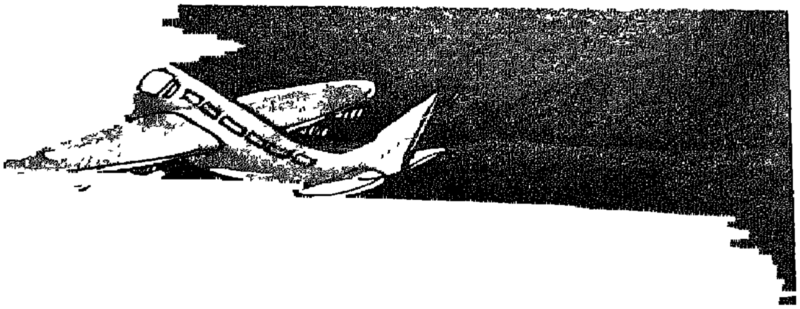
And **El**ectricity and **Mag**netism produce **Mo**tion, that is a motor."

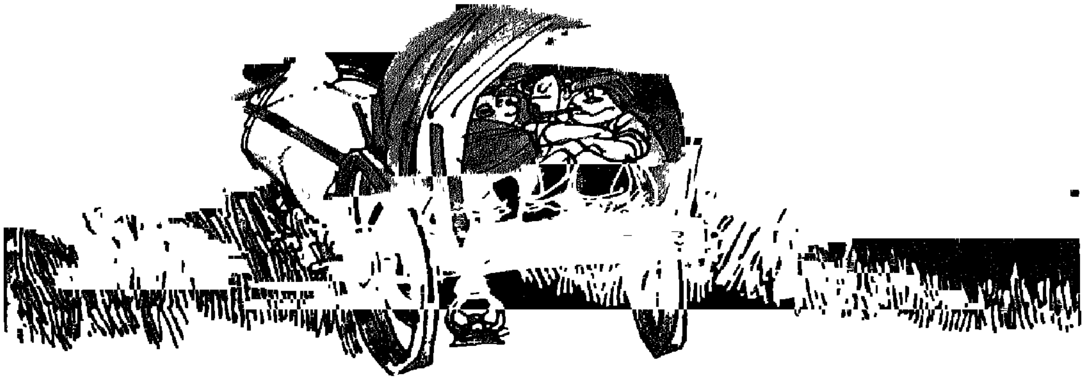
Sudha looked at Bipin in appreciation. Raja was a little disappointed that he could not think of it. He had read about generators and motors in Abdul's book. Bipin began to sing "Yo Ho Ho Ho," loudly when the Principal walked in and made him stand on the bench.


LIGHT
FOOD INTO CHEMICAL ENERGY
CHEMICAL TO MECHANICAL TO GRAVITATIONAL ENERGY
CHEMICAL ENERGY CHANGES TO MECHANICAL
CHEMICAL ENERGY PRODUCES BODY HEAT AND ELECTRICITY
CHEMICAL ENERGY TO SOUND ENERGY


I drink about 10 litres of fuel every kilometre. That's what gets me high
Old is gold
Are you in a hurry? Need luxury? Step into the car.
Be a Bussy person and save fuel
My dessert is my own fat when I cross a long desert.
Hike if you like
Bike if you don't hike. It's cheap either way
They retired me in favour of diesel and electric engines because I am not efficient. I am all steamed up.
Yesterday: fluttering sails and slaves with oars
Today: with diesel my engine roars
Tommorrow's energy: the nuclear stores.

In India, out of a total of 40 million tonnes, 16 million tonnes of oil is used every year for transport alone.





It was a summer evening.

Raja was sitting in the verandah with his parents. Prabha was also there. Prabha suddenly pointed to an aeroplane which was flying across, flashing coloured lights, while a bullock cart with a lantern in the rear moved along a mud track. "Isn't it funny father, seeing a plane and a cart together?" Prabha laughed.

"Well, at present in India we need both aeroplanes and bullock carts," father said. "Although we use tonnes of oil for transport every year, we also have to use animal energy particularly in small towns and villages."

"Doesn't it hurt the animals to pull such heavy loads?" Prabha asked.

"It must. But we have little choice at the moment, Prabha," father said.

"We should design the carts in such a way that the animals find it easier to pull the carts. We are using trains more and more for carrying loads and we also use trains and buses for passengers."

"What about planes?" Raja asked.

"Of course we need them when we have to travel far or fast," father said.

"I have never been on a plane, father," Raja said.

"You will one of these days, Raja," father said with a smile.

"Do not waste" — Ant

Raja was in his study doing his homework when he saw a black ant trying to grab a large grain of sugar that was lying on the table.

Raja moved the grain away with the tip of his pencil.

The ant stopped and again moved towards the grain of sugar.

Raja promptly moved it again. But it fell off the table. The ant stopped and in a tiny shrill voice told Raja, "This is not fair. We have to work for every bit of food that we eat. We do not waste food as some of you people do."

"I am sorry," Raja said, and he bent down to look for the sugar grain but he could not find it.

"Never mind," the ant said. "I shall find it. All I wanted to tell you is that you should not waste food. There are many young children who are poor and do not have enough food although they work as hard for their living as we ants do."

Raja felt a bit ashamed because he often left food on his plate or milk in his cup and he hadn't realized how others had to work hard for their meals.

"And if you don't mind my telling you," the ant continued, "I often notice that you do not switch off the light and the fan when you go out of the room. You just waste energy. Anyway, I must not waste my time. Goodnight," and the ant hurriedly moved away.

Mass changes into energy

"The Sun and the stars produce Nuclear energy," Keshav told Raja one day when they were walking home from the playground.

"What is nuclear energy?" Raja asked.

"Energy from the nucleus," Keshav said.

"But the nucleus of an atom is very small. How much energy can it hold?"

Raja was puzzled. Keshav did not know the answer.

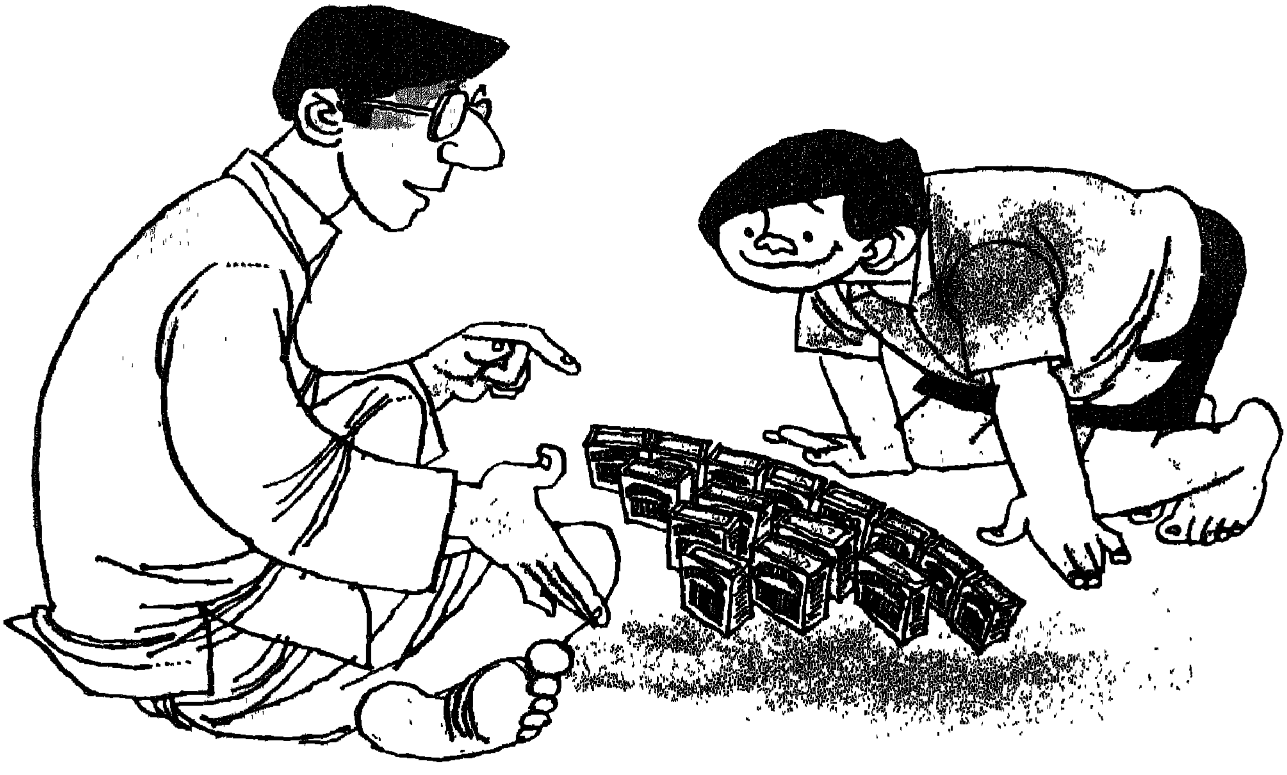
Raja asked father about it. "You are quite right. The nucleus of an atom is very small. But it does not hold energy like a cup holds water. A part of its mass changes into energy," father said.

Raja was more confused.

"Let me explain," father said. "Have you still got your match boxes?"

When he was in the 3rd Standard, Raja used to collect match boxes of different makes. He ran inside and got them although he could not figure out what his match boxes had to do with nuclear energy. Father arranged the boxes in a formation and knocked down the first match box.

The first box knocked over the two boxes in front of it, these two knocked over the four in front of them, those four knocked eight more and so it went on. In a second almost all the boxes had fallen down.



"This is called a chain reaction," father said. Now there are some atoms like Uranium whose nuclei are heavy. If you hit such a nucleus with a neutron, two or three neutrons will be produced. These neutrons hit other nuclei which produce more neutrons. A chain reaction is set up. In a moment a very large number of nuclei break up. With the breaking (or FISSION) of each nucleus
ENERGY IS PRODUCED.

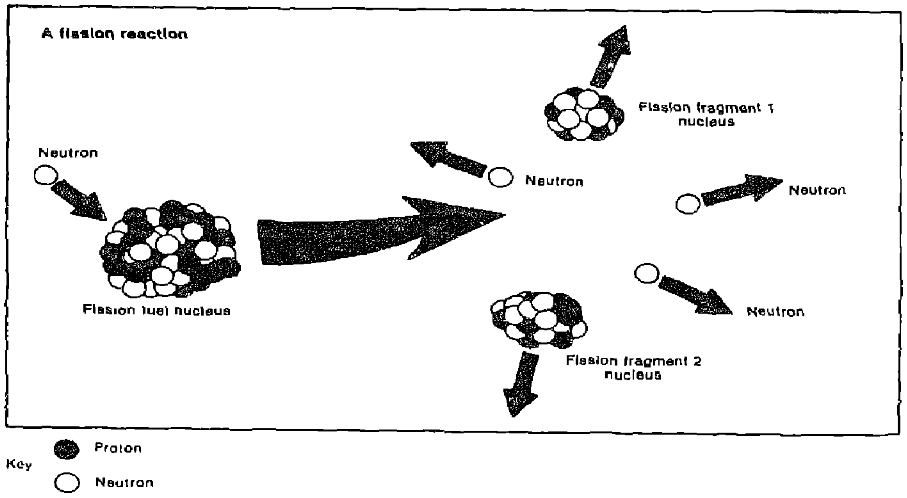
Since billions and billions of atoms are involved in the chain reaction, an enormous amount of energy is produced.

When a small atom bomb fell on Hiroshima in Japan, the town was destroyed. 70,000 people were instantly killed. Many died afterwards.

If we can somehow stop or catch some of the neutrons, the chain reaction can be controlled In a nuclear reactor, the chain reaction is not allowed to proceed merrily. Some of the neutrons are stopped by a kind of trap.

The large amount of heat produced turns water into steam. The steam can be used to turn a turbine and a generator.
ELECTRICITY IS PRODUCED.

"At present there are nuclear reactors in India producing more than 1300 megawatts of power," father said." We have to be very careful with nuclear reactors. If something goes wrong, a nuclear reactor may become a source of deadly radiations."

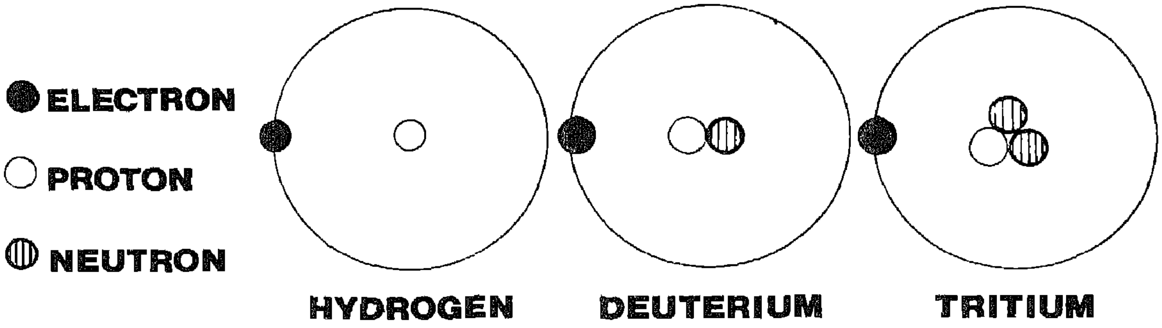


A fission reaction

From where does the sun get its energy?

“But what about the energy of the Sun?” Raja asked.“The energy inside the Sun is not produced by the breaking of nuclei. Something opposite happens there. It is called FUSION. Fusion of certain forms of Hydrogen produces solar energy.

“ Hydrogen has three forms :



If deuterium and tritium can be made to unite or fuse, Helium and a neutron are produced along with A VERY LARGE AMOUNT OF ENERGY.

In both, FISSION and FUSION, a small amount of the mass of the nuclei is lost, but 90,000,000,000 times of this mass appears as Energy as Einstein had predicted. Deuterium present in one litre mug of water can produce:

1,500,000 units of electricity.

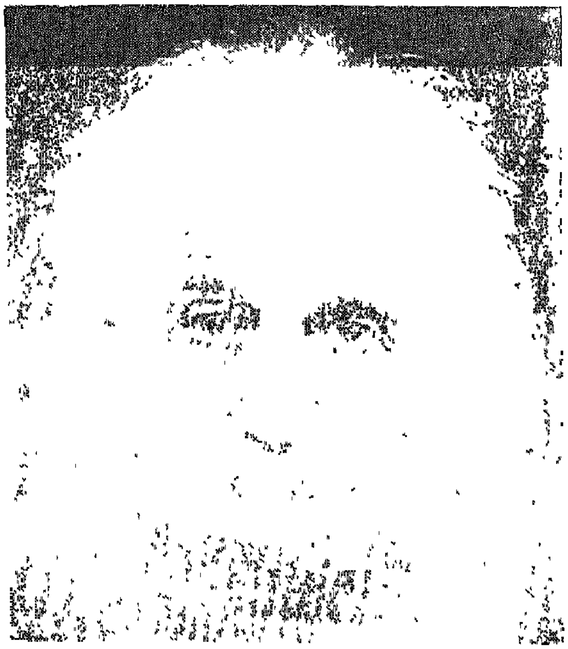
In our house we use 100 units of electricity in a month. Electricity from one mug of water should last us 1275 years!”

“But why don’t we produce electricity that way?”Raja asked, totally perplexed. “Fusion occurs at the very high temperature of 82 million degreeCelsius. (Our body temperature is 37 degrees). It is not easy to produce such a high temperature. A lot of research is now going on to produce energy from FUSION.

If we succeed, the Deuterium present in all the seas will produce 900,000,000,000,000,000,000,000 units of energy. Even a small fraction of this energy should last all of us on this earth a billion years unless we destroy ourselves by nuclear bombs,” father said.

“Why should we destroy ourselves father?” Raja looked frightened.

“I do not know the answer. We all know that nuclear bombs maydestroy us. We still keep making them. Isn’t it strange?”



Albert Einstein

Albert Einstein is probably one of the greatest physicists the world has ever produced.

Einstein was born on 14 March 1879 in Ulm, Germany. Einstein was keen on mathematics and physics from early childhood. He had taught himself calculus when he was twelve years old. After his graduation in 1900, Einstein got a job as a technical expert in the Swiss Patent Office in Berne.

He had plenty of time to pursue his studies there. In 1905, Einstein published five papers. Any one of these papers would have made him famous.

One of these papers was on the special theory of Relativity. Another paper showed that matter and Energy are related by the equation $E = mc^2$ where E is energy, m is mass and c is the velocity of light.

He made many more major discoveries later. In 1916, he published his paper on the general theory of Relativity. Einstein was awarded the Nobel Prize in 1921.

He spent his spare time playing the violin. Einstein was a great humanist. He was persecuted by the Nazis (Hitler's party) because he was a Jew. He left Germany and joined the Institute of Advanced Study in Princeton in the United States.

Einstein had feared that the Nazis would develop atom bombs and he urged President Roosevelt of the U.S. to begin development of atom bombs. But he was very unhappy when atom bombs were used to kill thousands of innocent people in Japan. He tried to persuade world powers to stop producing nuclear bombs. But nobody listened to him.

Einstein died in Princeton on April 16, 1955.

A pledge

Raja's school had closed for the summer. Coming home Raja was having his usual ride on Sthula's back when he told Sthula, "Our school has holidays for two months, Sthula."

"Won't you be coming this way for two months then?" Sthula asked

"Of course I shall come," Raja said. Sthula was pleased.

"Have you heard of Energy Forests, Sthula?" Raja asked.

"No I have not," Sthula admitted.

"Miss Leela told us that trees are being planted, trees that grow very fast to provide wood and fuel. Eucalyptus, Subabul are such trees," Raja said

"Who are planting these trees? I can only see some men cutting trees from the forest. I don't like it," Sthula said. "At this rate there won't be any trees left in this forest. Where will we live?"

"Why don't you chase them away?" Raja asked.

"I do when I see them. Those men carry guns. They kill small animals and cut trees one after another. I don't like them," Sthula said.

"Are they there now? Let us have a look." Raja said.

Sthula changed direction and started moving towards the denser part of the forest.

"Don't talk," Sthula warned Raja.

Raja was thrilled. He was a little afraid also but he had nothing to fear when Sthula was there.

Sthula moved stealthily. Suddenly Raja saw a few men sitting on a log and a few others cutting a big tree. They looked dangerous. Two of them had guns.

"That elephant is here again," one of the men told his companions.

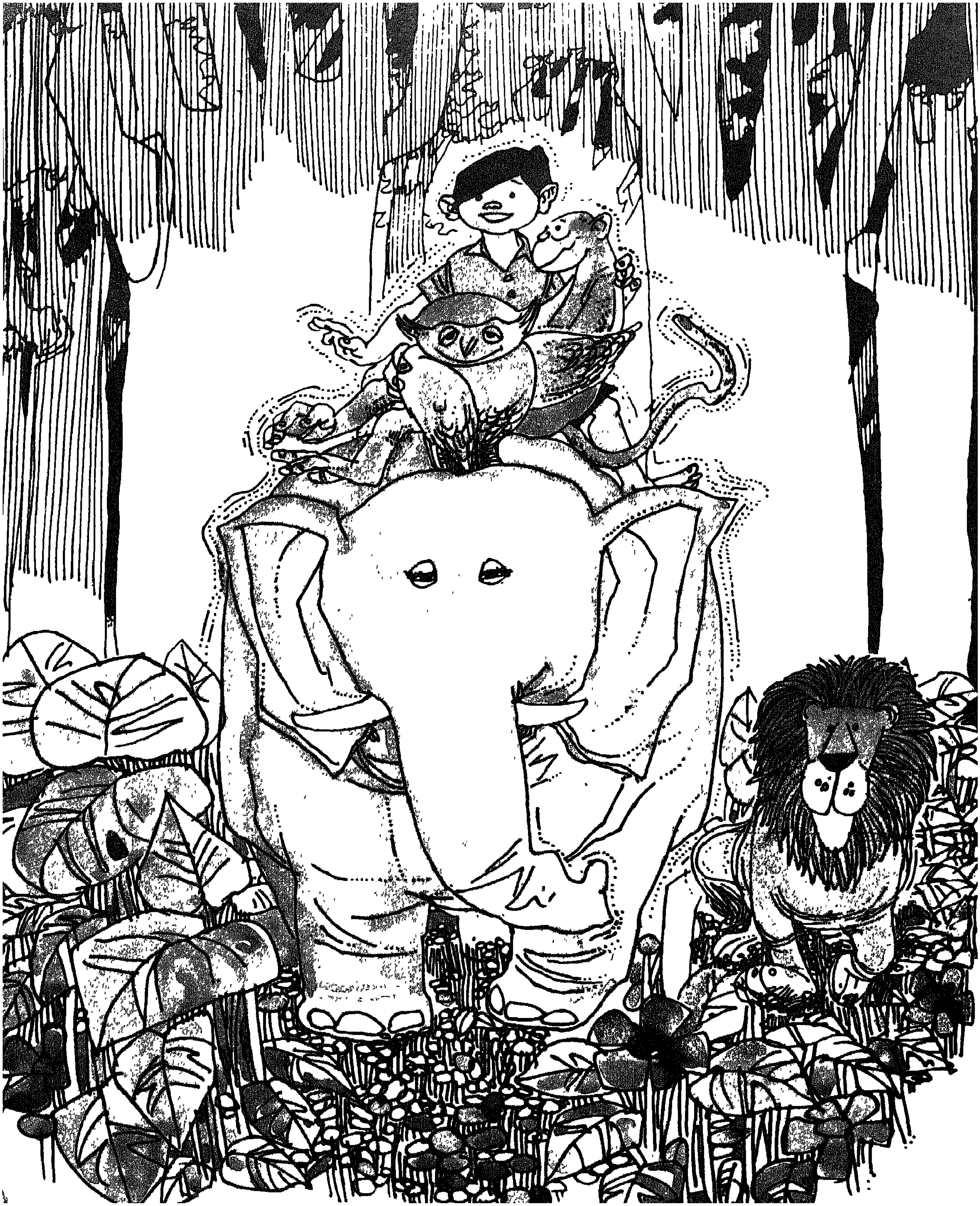
"He has beautiful tusks, hasn't he?"

"Let us get him. His tusks will fetch a lot of money," said another

The leader of the group, a fierce looking man turned in the direction where Sthula was standing and said, "That's a good idea. Ramu, is your gun powerful enough to kill an elephant?"

"It is Sir, but there is a boy sitting on the elephant," the man named Ramu said.

"Never mind that. Aim low, the boy won't be hurt. We shall then take care of him," the leader said.



"Let us get back Raja. I don't care about me, so much, but I don't want you in danger," said Sthula and turned back.

Raja was afraid lest those men should try to shoot Sthula. He looked back and saw the men creeping behind them. Ramu was aiming his gun at Sthula. "Sthula run," Raja shouted. But before he could say it, Ramu fired. He missed. The bullet just grazed past Sthula's belly. Ramu was taking a second aim when a loud roar could be heard and a lion leapt in. Ramu, his leader and all the men ran for dear life. They jumped on a truck and sped away as fast as they could.

It was Pashuraj. He had arrived just in time.

"Thank you Pashuraj," Sthula said.

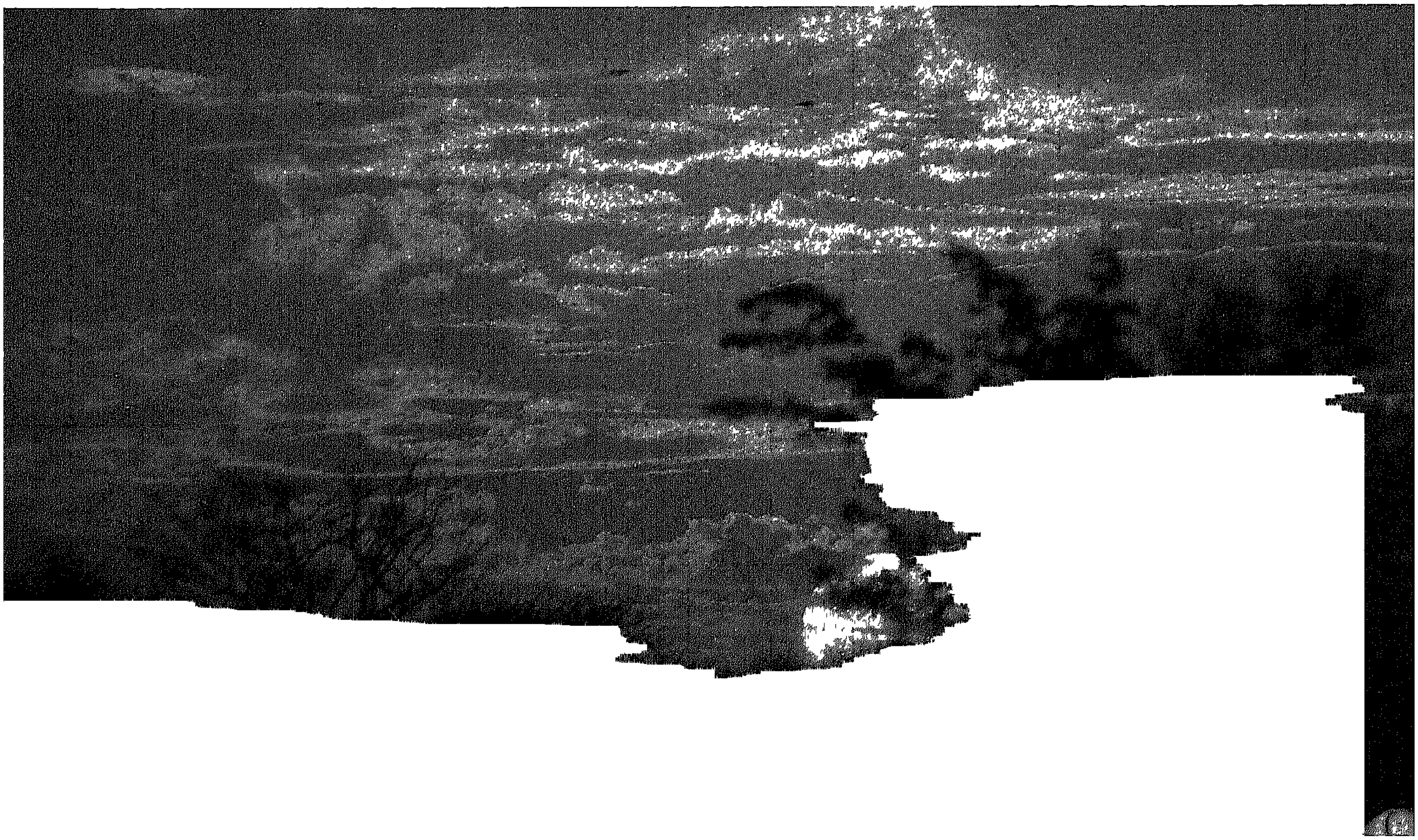
"Who told you we were here?" Raja asked.

Pashuraj looked up. It was Vidwan Markata who was looking very pleased with himself.

"Well, I saw you coming this way and followed you hoping to give you a pleasant surprise. As soon as I saw those men I sensed danger and informed Pashuraj." Pashuraj looked very proud. Suddenly Owl appeared from nowhere. Everyone was pleased to see him. After Owl heard everything he said, "From now on we shall take care of this forest.

TREES GIVE US LIFE AND WE SHALL SAVE TREES."

They all agreed and started walking back. Raja was getting late for home.



CROSSWORD PUZZLES

①

A^{1}			M^{2}
	▨	▨	
	▨	▨	
▨	S^{3}		

ACROSS

1. A tiny particle.
3. Gives most of our energy.

DOWN

1. Helps burning.
2. Gives tidal energy.

②

T^{1}			
	▨	▨	▨
	▨	▨	2
3			F

ACROSS

1. Makes food in sunlight.
3. Kitchen of a tree.

DOWN

1. Some trees are very ____________
2. ____________ trees are destroyed
   We shall also be destroyed.

③

F^{1}			2
	▨	▨	
	▨	▨	
3			T

ACROSS

1. Gives us energy.
3. Where the Sun rises to give us heat and light.

DOWN

1. We need it to cook our food.
2. This has to be balanced.

④

▨	P^{1}	^{2}	W^{3}		^{4}
▨	▨	^{5}		N	O
▨	▨	▨	T	▨	C
S^{6}	▨	T^{7}		^{8}	
^{9}	N		R		Y
	▨		▨		▨

ACROSS

1. You need more of it, the faster you run.
5. One billionth.
7. Makes excellent furniture but we should not cut trees to obtain them.
9. It is a measure of the capacity of doing work.

DOWN

2. The switch is ______.
3. We cannot live without it.
4. The surface of the moon is like this.
6. A lot of energy is stored here.
7. It gives you energy when you are cold.
8. The Earth's ______ is estimated to be more than 3 billion years.

⑤

F^{1}	^{2}	R	^{3}		▨	H^{4}	
▨	M	▨		▨	^{5}	▨	▨
▨		▨		▨	O^{6}		^{7}
^{8}	E		▨	▨		▨	E
▨		▨	^{9}	▨	L^{10}		
▨	E	▨	^{11}		E	▨	
▨	▨	▨		▨	▨	^{12}	R
^{13}		W				▨	▨

ACROSS

1. Capacitance is the capacity of a body to store electric charge. It is measured in ______ named after a great scientist.
4. Power used to be measured in a unit that described the power of an animal. By pulling a rope connected through a pulley, it raised 14,700 kg weight in one minute.

   The inventor of this unit was James Watt who used this unit for his engines. Now-a-days the unit of power is Watt. [Don't we say"a 100-Watt bulb?"] 750 Watts make a H ______.
6. Electric current meets with resistance as it flows. The unit of resistance is ______ named after a German school master who proposed in 1826 that the flow of electric current increases with voltage (or pressure) and reduces as the resistance of the path of its flow increases.

   [This law is described as Current = Voltage/Resistance]. The school master lost his job for publishing his theory. Twenty three years later he became a professor of physics.

8. We rob the liquid a ———— steals from flowers. The liquid gives us energy and the wax gives us light.

10. There is a ———— of energy stored in the oceans, but until now it has not been easy to draw this energy out.

11. We extract metals out of an ————.
12. Either, ————
13. Force is measured in ————, named after one of the greatest scientists of all times.

DOWN

2. The flow of electric current is measured in this unit named after a French scientist. It represents the flow of 6.28 billion electrons in one second past a given point.

3. When there is a + sign you do this.

5. Energy is measured in this unit. It is equivalent to 1 watt of power working for one second and is equal to one watt–second.

7. Unit of length. It is an alternative spelling.

9. Pressure of electricity is measured in this unit named after an Italian Professor who did not believe in Galvani's theory of animal electricity.

QUIZ

Set A

1. Who invented the first thermometer?
2. Who showed that plants respond to pain?
3. Who discovered Radium?
4. Who discovered Neutrons?
5. Who discovered Electrons?
6. Who wrote the Principia Mathematica?
7. Who showed that mass can be changed to energy?
8. Who separated Oxygen?
9. Who invented lightning arresters?
10. Who explained correctly, the phenomenon of burning?
11. Who discovered X'rays?
12. Who made the first atomic reactor?

Set B

1. What is Will-o'-the-wisp made of?
2. What is Carbon Monoxide?
3. How many electrons are there in an Oxygen atom?
4. How many electrons are there in a Carbon atom?
5. Is energy released when Hydrogen and Oxygen combine to give water?
6. What is Deuterium?
7. Helium is an inert gas which means it does not combine with other elements. Do you know why?
8. What is the wavelength of blue light?
9. Why is Red used as a danger signal?
10. How long does it take light to travel from the Sun to the Earth?
11. Can you calculate the distance of the Sun from the Earth?
12. How long is a light year?

Answers to Cross word Puzzles

[1] Across: 1. Atom 3. Sun
Down: 1. Air 2. Moon

[2] Across: 1. Tree 3. Leaf
Down: 1. Tall 2. If

[3] Across: 1. Food 3. East
Down: 1. Fire 2. Diet

[4] Across: 1. Power 5. Nano 7. Teak 9. Energy
Down: 2. On 3. Water 4. Rocky 6. Sea 7. Tea 8. Age

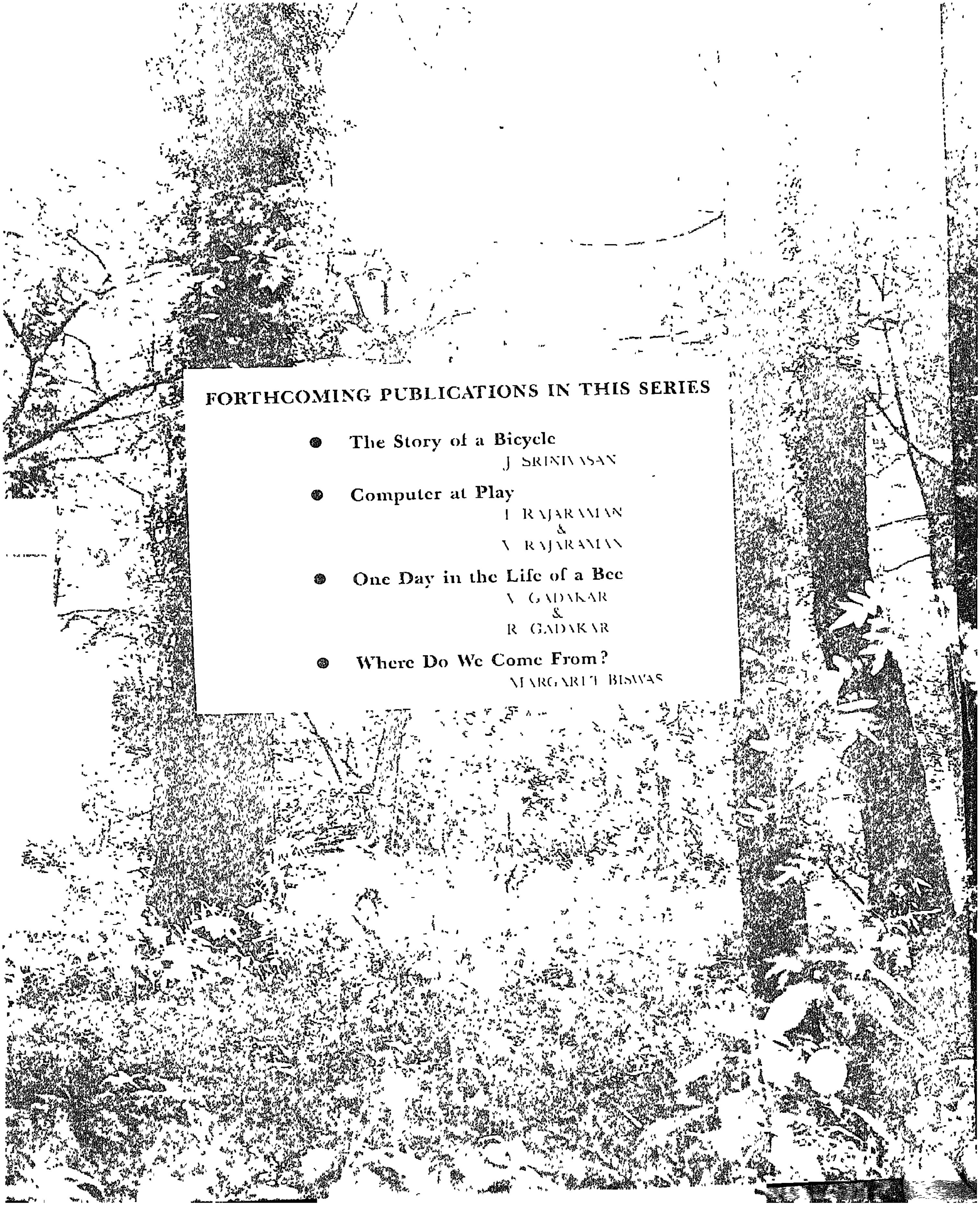
[5] Across: 1. Farad 4. HP 6. Ohm 8. Bee 10. Lot 11. Ore
12. Or 13. Newton
Down: 2. Ampere 3. Add 5. Joule 7. Meter 9. Volt

Answers to Quiz

Set–A 1. Galileo, 2. Acharya Jagadish Chandra Bose, 3. Marie Curie and Pierre Curie, 4. James Chadwick, 5. J.J.Thomson, 6. Isaac Newton, 7. Albert Einstein, 8. Joseph Priestley, 9. Benjamin Franklin, 10. Antoine Lavoisier, 11. Wilhelm Konrad Roentgen, 12. Enrico Fermi.

Set–B 1. Methane gas, 2. It is a compound made of one atom of Carbon and one atom of Oxygen. It is poisonous. 3. Eight, 4. Six, 5. Yes, 6. Deuterium is a special type of Hydrogen which has a neutron and a proton. 7. Helium is inert because its first shell has both the electrons that it needs, thereby making it very stable, 8. Blue light has the wave-length of about 4500 Angstrom unit. One Angstrom is equal to 1/10,000,000,000 th part of a metre. A full-stop(.) can accommodate about ten thousand waves of blue light. 9. The wavelength of Red is about 7300 Angstrom. Longer wavelength helps Red light to travel longer distance without being scattered. 10. Approximately 8 minutes, 11. The distance between the Sun and the Earth is not constant. It is 145 million kilometres when they are closest and 155 million kilometres when they are farthest from each other. 12. A light year is a measure of distance. It indicates the distance travelled by light in one year. There are
365.25 × 24 × 60 × 60 = 31,557,600 seconds in a year. Light
days hours. mins. secs.
travels 300,000 km per second, 9467 billion kilometres in a year ~~or approximately 9.5 trillion~~ kilometres.

National Institute of Education



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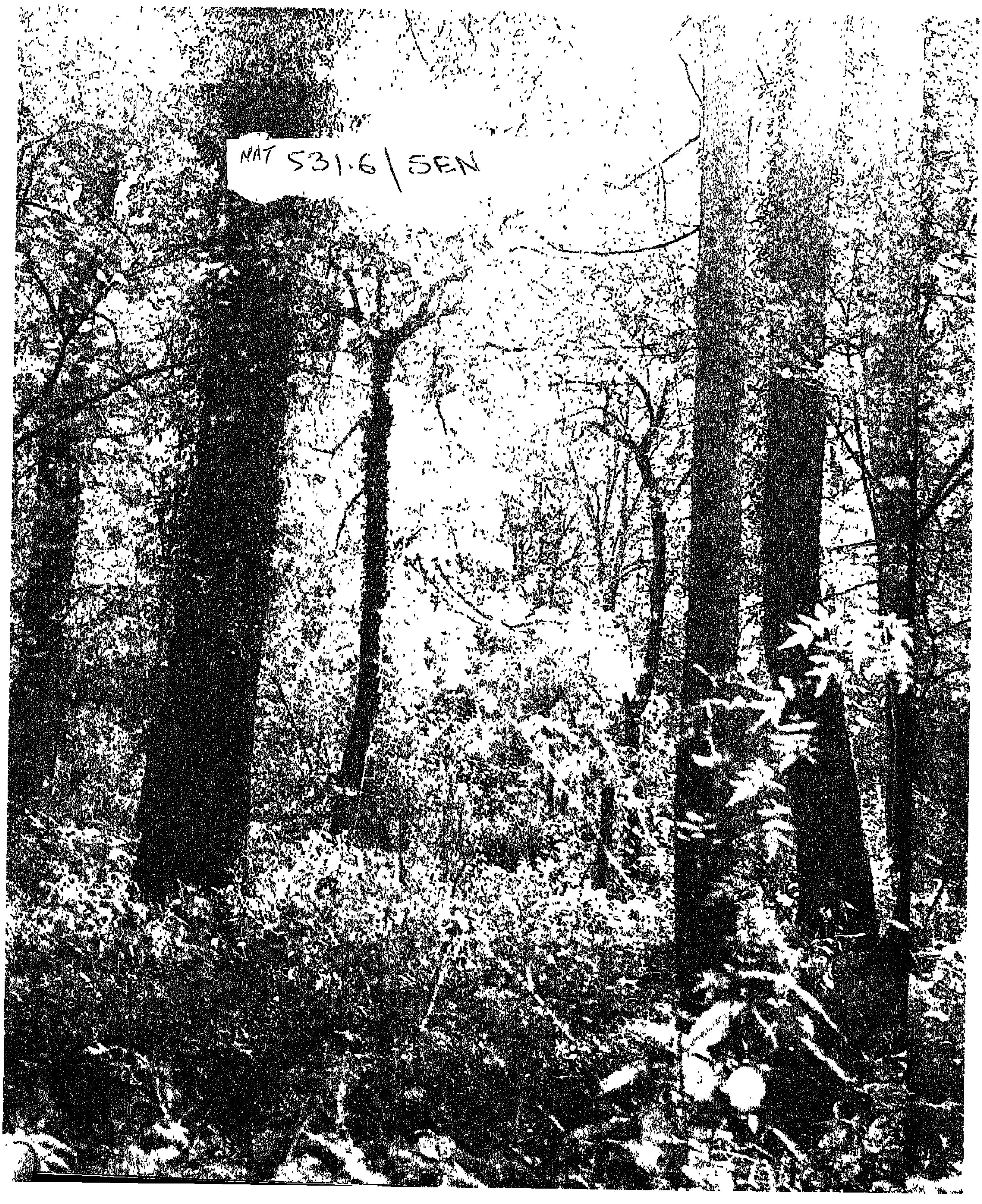

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